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AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

Art. I.—*Contributions to Meteorology*; by Elias Loomis, Professor of Natural Philosophy in Yale College. Twentieth paper. With Plates I and II.

[Read before the National Academy of Sciences, Nov. 13, 1883, and April 15, 1884.]

Reduction of Barometric observations to sea-level.

In my fifteenth paper of contributions to Meteorology, I endeavored to determine the proper reduction to sea-level of barometric observations made at elevated stations. For this purpose I made an extensive comparison of observations at five mountain stations; three in the United States and two in Europe. The reductions deduced from these observations were compared with the reductions computed from the theories of Laplace and Plantamour, and exhibited very great discrepancies. For each of the stations the discrepancies appear at the lowest pressures, and also at the highest pressures, while for a medium pressure the observed reductions agree with the computed reductions. In order to discover if possible the cause of these discrepancies. I selected for examination all the cases in which during a period of three years there was a decided area of high or low pressure near either of these five stations. Table I shows the most remarkable cases of barometric minima on Mt. Washington during a period of three years. Column first gives the number of reference; column second the date of the barometric minimum; and column third gives the height of the barometer at sea-level deduced from the observations at Burlington, Vt. and Portland, Me. The distance of Mt. Washington from Portland is almost exactly two-thirds of its distance from Burlington, and I have assumed that the pressure at sea-level under Mt. Washington is given by the formula $\frac{1}{5}(2B+3P)$. The temperature at sea-level given in column fourth is deduced from the observations at Burlington and Portland by the same formula. Column fifth shows the pressure observed on Mt. Washington, column sixth the temperature on Mt. Washington and column seventh gives the half sum of the temperatures in columns four and six.

The numbers in this table were arranged in the order of the mean temperatures given in column seventh, and were divided into four equal groups and the average of the numbers in the several columns for each group was computed. The results are given in the first five lines of table III, under the heading barometric minima; and these results may be regarded as normal values deduced from the barometric minima of three years.

I next proceeded to compare these results with theory. Column sixth of table III shows the Mt. Washington observations reduced to sea-level by the use of Guyot's tables as contained in his collection of tables, series D, page 33, employing the mean temperatures given in column fifth. Column seventh shows the difference between the numbers in columns one and six.

It has been a common opinion among meteorologists that anomalies like these shown in column seven result from the erroneous assumption that the mean temperature of the air column between the upper and lower stations is equal to the half sum of the temperatures observed at the two stations. In order to test this explanation I computed what must be assumed as the true temperature of the air column in order that the Mt. Washington observations, reduced to sea-level by the Laplace formula, might agree with the barometric heights observed at sea-level, and the results are shown in column eighth. It will be seen that the differences between the numbers in columns five and eight range from 5° to 10°.

I next computed the reduction of the Mt. Washington observations to sea-level by Ferrel's tables, published in his Meteorological Researches, Part III, pages 40–41, and the results are shown in column ninth. Column tenth shows the difference between the numbers in columns one and nine; column eleventh shows what must be assumed as the true temperature of the air-column in order that the Mt. Washington observations reduced to sea-level by Ferrel's tables may agree with the barometric heights observed at sea-level. It will be seen that the differences between the numbers in columns five and eleven range from 8° to 15°. Some remarks upon these results will be found on a subsequent page.

TABLE I.—*Barometric minima on Mt. Washington.*

Date.	Sea level.		Mt. Wash'n.		Mean temp.	No.	Date.	Sea level.		Mt. Wash'n.		Mean temp.
	Bar.	Therm.	Bar.	Ther.				Bar.	Therm.	Bar.	Ther.	
1872.							1874.					
Sep.20.1	29·69	55°·2	23·45	39	47°·1	55	Jan 16.1	29·67	9°·8	22·72	−25	−7°·6
Oct. 2.2	·74	53·8	·32	24	38·9	56	26.1	30·53	−9·8	23·10	−39	−24·4
14.1	·45	41·6	·23	27	34·3	57	28.3	29·80	20·2	·11	4	12·1
20.1	·97	37·0	·43	17	27·0	58	30.1	30·32	0·0	·20	−30	−15·0
Nov. 7.3	·26	40·4	22·78	20	30·2	59	Feb 11.1	29·65	16·0	22·97	−15	0·5
8.1	·33	41·6	·80	21	31·3	60	16.2	·45	34·4	23·03	13	23·7
15.1	·58	36·6	23·15	22	29·3	61	17.1	·65	23·2	·02	−5	9·1
29.2	·72	32·6	22·89	13	22·8	62	27.2	·92	26·6	·14	−4	11·3
30.1	·45	15·8	·63	5	10·4	63	Mar10.1	·32	20·2	22·82	11	15·6
30.3	·63	16·2	·73	3	9·6	64	12.3	·41	12·2	·77	−9	1·6
Dec. 1.1	·84	20·6	·85	4	12·3	65	23.1	·57	24·0	·92	−5	9·5
3.1	·56	36·2	23·02	17	26·6	66	23.3	30·05	12·4	23·00	−18	−2·8
10.1	·61	11·8	22·78	3	7·4	67	Apr. 3.2	29·63	40·6	·11	4	22·3
22.2	30·17	6·6	23·05	−9	−1·2	68	4.2	·90	22·6	·07	−13	4·8
24.3	·48	−8·8	·05	−16	−12·4	69	26.1	·38	32·6	22·95	11	21·8
28.1	29·95	−1·8	22·75	−20	−10·9	70	30.2	·38	38·2	·67	8	23·1
1873.						71	May 1.1	·35	39·6	·82	10	24·8
an. 6.1	·62	32·8	·98	13	22·9	72	6.1	·73	45·0	23·38	18	31·5
9.2	·79	26·2	23·07	12	19·1	73	22.1	·70	47·0	·37	24	35·5
11.3	30·15	8·2	·06	−11	−1·4	74	June 1.1	·57	56·8	·38	34	45·4
25.1	29·73	13·4	22·98	1	7·2	75	13.1	·81	57·4	·48	29	43·2
28.3	·86	14·8	23·00	−1	6·9	76	Sep.30.2	·39	55·6	·06	27	41·3
eb. 8.2	·46	40·4	·01	16	28·2	77	Oct. 1.1	·65	48·2	·28	20	34·1
10.1	30·10	0·0	22·96	−4	−2·0	78	11.1	·63	54·6	·37	28	41·3
22.2	29·36	19·8	·66	2	10·9	79	19.1	·70	40·8	·25	14	27·4
24.1	·47	−1·2	·51	−14	−7·6	80	30.1	·72	53·8	·38	27	40·4
Mar. 3.3	·53	16·2	·92	4	10·1	81	Nov11.3	·86	34·4	·23	9	21·7
9.1	·53	31·4	·94	14	22·7	82	21.1	·45	33·2	·02	9	21·1
16.3	·60	27·6	·74	7	17·3	83	24.1	·09	37·6	22·62	15	26·3
24.1	·96	14·6	·92	3	8·8	84	29.2	·62	34·2	23·05	4	19·1
27.1	·57	19·2	·78	8	13·6	85	Dec18.1	·73	14·8	22·75	−19	−2·1
30.1	28·91	35·4	·72	23	29·2	86	24.2	·59	35·8	23·04	9	22·4
Apr14.1	29·61	36·6	23·10	20	28·3	87	29.2	·88	26·6	·02	−3	11·8
26.1	·47	43·0	·15	20	31·5	88	30.2	30·21	10·8	·01	−20	−4·6
M'y 13.2	·45	54·8	·18	31	42·9		1877.					
15.1	·64	41·2	·14	19	30·1	89	Jan. 3.1	29·80	7·4	22·78	−22	−7·3
June 5.1	·56	54·4	·46	40	47·2	90	4.1	·81	2·4	·76	−25	−11·3
20.2	·54	79·8	·47	49	64·4	91	7.2	·18	33·6	·64	11	22·3
July 6.1	·80	69·4	·68	44	56·7	92	14.1	·66	16·4	·83	−8	4·2
Au. 24.1	30·01	54·0	·62	27	40·5	93	24.3	·89	6·8	·77	−25	−9·1
Sep. 2.1	29·73	62·8	·51	36	49·4	94	Feb 13.1	30·11	13·6	23·04	−15	−0·7
20.2	·84	54·8	·40	24	39·4	95	18.1	29·62	18·0	22·83	−11	3·5
Oct. 7.1	·56	43·8	·44	34	38·9	96	19.1	·61	14·8	·83	−11	1·9
12.3	·72	48·0	·51	31	39·5	97	24.3	·64	33·4	23·24	16	24·7
27.2	·30	56·0	·21	34	45·0	98	Mar. 9.2	·13	42·2	22·86	28	35·1
Nov. 8.3	·44	44·2	·11	21	32·6	99	15.3	·72	23·4	·92	−8	7·7
13.2	·58	29·0	·03	9	19·0	100	19.1	·99	14·2	·98	−20	−2·9
18.2	28·88	31·2	22·56	30	30·6	101	29.1	·37	34·4	23·06	27	30·7
25.2	29·26	25·4	·84	8	16·7	102	Apr. 6.1	·44	37·6	·05	14	25·8
26.2	·80	14·4	·91	−17	−1·3	103	20.3	·51	43·2	·26	25	34·1
Dec. 4.3	·82	43·2	23·31	15	29·1	104	May 3.3	·60	45·4	·10	16	30·7
13.3	·39	18·6	·07	22	20·3	105	June 4.1	·71	70·6	·52	39	54·8
14.2	·79	24·5	·09	−1	11·7	106	22.1	·61	62·0	·39	34	48·0
28.2	·42	26·0	22·76	−5	10·5	107	July 2.1	·64	68·2	·54	43	55·6
29.3	·57	25·4	·90	7	16·2							

I next selected for examination all the cases in which, during a period of three years there was a decided area of high pressure over Mt. Washington. The results are shown in table II, which is constructed upon the same principles as table I. These numbers were then arranged in the order of the mean temperatures given in column seventh and were divided into four equal groups, and the average of the numbers in the several columns for each group was computed. The results are given in the first five lines of table III under the heading barometric maxima.

I then proceeded to compute the remaining columns of the table in the same manner as has been explained for barometric minima.

We see from table III that if we undertake to explain the differences between the pressures observed at sea-level and the Mt. Washington observations when reduced to sea-level in accordance with theory, we must admit errors of ten degrees in the assumed temperature of the air-column when the computations are made by Guyot's tables, and errors of fifteen degrees when the computations are made by Ferrel's tables; and this is true not simply for exceptional cases but for the average of all the barometric minima during a period of three years. The question to be decided is, can errors of such magnitude be admitted? In order to decide this question, I have consulted all the available observations of the thermometer made in the neighborhood of Mt. Washington. In the Annual Report of the Chief Signal Officer for 1873 is given a series of hourly observations for May 1873 on the summit of Mt. Washington and also at a station situated on the side of the mountain 3387 feet below the summit; and for the month of June 1873 is given a series of hourly observations on the summit of Mt. Washington and at three stations on the side of the mountain, one situated 732 feet below the summit, a second 2227 feet below the summit, and a third 3387 feet below the summit. These observations can be compared with the tri-daily observations made at Burlington and Portland, and thus for the month of May we have the temperature given at one station intermediate between sea-level and the summit of Mt. Washington, and for the month of June we have the temperature at three intermediate stations. As the evidence for the month of June is much fuller than for the month of May, I have selected this month for a careful comparison and the details are given in table IV, where column first shows the day of the month and the four following columns show the temperatures observed at 7.35 A. M. at the elevations indicated at the top of the columns. The sixth column shows the temperature deduced from the observations at Burlington and Portland by the formula $\frac{1}{5}(2B+3P)$.

Table II.—*Barometric maxima on Mt. Washington.*

Date.	Sea level.		Mt. Wash'n.		Mean temp.	No.	Date.	Sea level.		Mt. Wash'n.		Mean temp.
	Bar.	Therm.	Bar.	Ther.				Bar.	Therm.	Bar.	Ther.	
1872.							1874.					
Sep. 11.1	30·33	57°·0	24·15	48	52°·5	54	Jan. 3.1	30.28	34°·6	23·93	33	33°·8
24.2	·32	67·2	·20	40	53·6	55	6.1	·63	20·8	24·00	27	23·9
Oct. 6.1	·15	58·8	·01	44	51·4	56	18.2	·37	30·8	23·97	29	29·9
22.1	·19	47·6	·06	40	43·8	57	20.3	·61	13·2	·95	14	13·6
24.3	·51	38·6	·18	33	35·8	58	Feb. 2.1	·81	−10·8	·89	0	− 5·4
29.3	·62	34·2	·16	26	30·1	59	15.1	·28	26·0	·80	16	21·0
Nov. 5.3	·30	38·2	23·95	24	31·1	60	18.3	·39	18·0	·90	20	19·0
11.1	·26	34·2	·89	24	29·1	61	22.2	·28	31·6	·84	29	30·3
17.3	·48	28·0	·84	12	20·0	62	Mar. 6.1	·48	17·2	·79	6	11·6
Dec 12.1	·38	6·4	·61	3	4·7	63	16.1	·43	28·6	24·00	37	32·8
18 1	·32	15·2	·69	7	11·1	64	17.1	·34	38·4	23 95	31	34·7
19.3	·45	22·4	·75	7	14·7	65	Apr 13.3	·25	34·2	·83	25	29·6
30.3	·45	1·6	·68	− 2	− 0·2	66	17.1	·29	33·4	·80	19	26·2
1873.						67	18.2	·35	43·6	·92	19	31·3
an. 2.1	·49	6·0	·82	5	5·5	68	M'y 12.1	·39	51·2	24·09	37	44·1
5.1	·31	21·2	·79	17	19·1	69	29.2	·13	64·8	·07	52	58·4
7.3	·33	18·2	·76	11	14·6	70	Jun 16.1	·11	67·6	·08	45	56·3
13.1	·43	8·8	·74	5	6·9	71	Jul. 19.1	·18	71·0	·15	51	61·0
15.1	·77	0·5	24·03	9	4·7	72	Au. 17.1	·20	66·2	·13	45	55·6
eb. 5.3	·13	14·0	23·52	9	11·5	73	26.1	·29	57·6	·09	37	47·3
15.3	·40	18·0	·83	10	14·0	74	Sep. 14.1	·26	60·8	·20	55	57·9
18.1	·35	20·2	·81	13	16·6	75	17.1	·29	57·2	·16	·49	53·1
Mar. 6.1	·57	12·8	·90	10	11·4	76	19.1	·32	56·0	·15	45	50·5
7.1	·37	25·0	·84	16	20·5	77	Oct. 7.3	·33	53·6	·09	35	44·3
15.1	·24	32·2	·76	13	22·6	78	24.1	·48	46·8	·21	36	41·4
28.2	·10	36·6	·70	16	26·3	79	25.1	·41	45·2	·19	40	42·6
Apr. 5.2	·16	38·6	·82	24	31·3	80	Nov. 4.2	·25	49·0	·00	35	42·0
16.3	·15	36 8	·89	23	29·9	81	7.3	·38	41·8	·05	34	37·9
May 8.1	·43	51·6	24·11	30	40·8	82	16.3	·52	32·8	·04	22	27·4
21.1	·31	55·2	·04	30	42·6	83	Dec. 1.1	·61	12·2	23·78	− 3	4·6
26.1	·06	66·4	·02	43	54·7	84	4.3	·52	20·4	·90	18	19·2
31.3	·24	48·4	·01	31	39·7	85	16.2	·29	22·4	·70	19	20·7
June 8.2	·16	66·6	·01	40	53·3		1877.					
25.2	·29	77·6	·25	55	66 3	86	Jan. 6.2	·18	26·6	·64	17	21·8
Jul 13.2	·09	75·2	·11	52	63·6	87	17.3	·54	15·4	·81	7	11·2
28.1	·15	70·6	·12	48	59·3	88	22.1	·31	21·2	·66	5	13·1
31.2	·06	75·0	·11	53	64·0	89	30.3	·46	30·2	·96	23	26·6
Au. 18.1	·24	63·2	·13	41	52·1	90	Feb. 3.1	·11	34·4	·74	22	28·2
21.1	·22	64·2	·17	51	57·6	91	4.2	·28	39·4	·82	22	30·7
29.1	·29	66·2	·18	47	56·6	92	11.2	·23	41·0	·77	23	32·0
Sep. 9.3	·36	53·8	·14	35	44·4	93	Mar. 1.3	·17	32·8	·70	19	25·9
17.3	·21	51·4	·07	31	41·2	94	13.3	·23	26·2	·71	16	21·1
22.1	·43	51·0	·07	30	40·5	95	25.3	·35	37·6	·94	30	33·8
27.1	·23	60·6	·07	50	55·3	96	Apr. 1.1	·39	42·2	·93	18	30·1
Oct. 10.2	·14	58·2	·06	50	54·1	97	13.2	·15	52·8	·80	20	36·4
15.3	·43	47·0	·13	32	39·5	98	23.1	·26	51·4	24·02	33	42·2
17.3	·32	41·8	·02	29	35·4	99	M'y 13.1	·27	56·2	·03	33	44·6
Nov. 2.1	·28	36·0	23·79	18	27·0	100	29.1	·20	66·6	·08	45	55·8
7.1	·42	27·4	·85	11	19·2	101	Jun 12.2	·18	70·6	·08	54	62·3
23.1	·33	26·2	·74	15	20·6	102	15.1	·15	69·4	·06	45	57·2
Dec. 2.2	·52	14·4	·94	8	11·2	103	Jul. 23.1	·20	70·0	·14	47	58·5
8.1	·64	18·6	24·05	15	16·8	104	27.2	·08	71·0	·05	61	66·0
16.3	·19	26·8	23·81	27	26·9	105	Aug. 1.1	·26	67·6	·19	52	59·8
22.3	·45	20·8	·83	10	15·4	106	24·1	·06	71·8	·09	56	63·9

TABLE III.—*Mean Results: Barometric Minima.*

Low'r station.		Upper station.		mean temp.	Redu'd Laplace	O−C	t'	Red'ed. Ferrel.	O−C	t''	Red'ed. Loomis
Barom.	Ther.	Barom.	Therm.								
Mount Washington, 6,285 feet above sea-level.											
			°	°			°			°	
29·910	8°·77	22·911	−16·00	− 3·62	29·728	+·182	−13·00	29·644	+·266	−18·68	29·635
·612	23·54	·925	+ 4·22	+13·88	·435	·177	+ 3·72	·376	·236	− 0·72	·377
·473	37·44	·985	+16·18	26·81	·299	·174	+16·68	·256	·217	+12·62	·264
·616	54·71	23·365	+31·00	42·86	·532	·084	+37·41	·498	·118	+35·00	·523
Pike's Peak, 8,794 feet above Denver.											
24·648	10·71	17·197	−10·12	+ 0·29	24·667	−·019	+ 1·19	24·585	+·063	− 3·02	24·567
·507	28·68	·290	− 0·08	14·30	·512	−·005	14·55	·453	+·054	+11·33	·445
·505	37·75	·381	+ 6·00	21·87	·492	+·013	21·19	·446	+·059	+18·52	·442
·574	52·63	·557	+18·17	35·40	·489	+·085	30·72	·456	+·118	+28·61	·465
Summit, 6,986 feet above Sacramento.											
29·849	42·21	22·893	21·87	32·04	29·883	−·034	33·97	29·844	+·005	31·76	29·818
·881	49·60	·921	28·79	39·19	·795	+·086	34·19	·761	+·120	32·03	·743
·909	55·55	23·003	30·78	43·16	·834	+·075	38·75	·801	+·108	36·72	·787
·891	62·84	·081	42·52	52·68	·778	+·113	45·81	·745	+·146	43·80	·744
Grand St. Bernard, 6,742 feet above Geneva.											
28·305	29·17	21·666	2·79	15·98	28·292	+·013	15·26	28·234	+·071	11·62	28·236
·371	36·99	·833	12·87	24·93	·357	·014	24·10	·310	·061	21·06	·317
·172	43·54	·752	22·89	33·22	·115	·057	29·71	·078	·094	27·08	·091
·276	55·36	·968	31·21	43·29	·237	·039	40·77	·202	·074	38·46	·227
Colle di Valdobbia, 7,831 feet above Alessandria.											
29·300	29·44	21·619	12·51	20·97	29·369	−·069	24·39	29·309	−·009	21·46	29·313
·340	43·18	·757	20·91	32·04	·339	+·001	31·95	·288	+·052	29·21	·302
·220	50·34	·756	27·39	38·87	·203	+·017	37·99	·161	+·059	35·66	·184
·297	62·80	·913	35·89	49·34	·223	+·074	45·18	·180	+·117	42·92	·220

Barometric Maxima.

Mount Washington and sea-level.											
30·468	14·66	23·812	8·73	11·70	30·614	−·146	19·99	30·549	−·081	16·64	30·548
·296	32·30	·842	21·03	26·67	·392	·096	32·57	·348	·052	30·05	·357
·324	47·67	24·042	33·48	40·57	·423	·099	47·07	·388	·064	44·77	·410
·188	67·00	·118	49·04	58·03	·257	·069	62·89	·223	·035	60·45	·269
Pike's Peak and Denver.											
24·922	23·80	17·774	6·44	15·12	25·181	−·259	28·40	25·122	−·200	26·14	25·114
·886	40·27	·836	15·19	27·73	·019	·133	34·95	24·980	−·094	33·02	24·981
·894	54·50	·929	23·42	38·96	24·943	·049	41·74	·911	−·017	40·00	·925
·905	69·32	18·097	37·44	53·38	·922	·017	54·59	·893	+·012	52·69	·930
Summit and Sacramento.											
30·305	39·32	23·486	23·57	31·44	30·668	−·363	52·50	30·628	−·323	50·38	30·600
·244	48·89	·472	30·74	39·81	·500	·256	55·05	·466	·222	53·02	·447
·123	62·07	·482	43·82	52·94	·292	·169	63·50	·258	·155	61·32	·256
29·973	76·14	·480	58·86	67·50	·059	·086	73·20	·024	·051	70·88	·018
Grand St. Bernard and Geneva.											
28·958	28·26	22·347	16·11	22·19	29·074	−·116	28·80	29·020	−·062	26·10	29·026
·801	44·17	·362	27·28	35·73	28·865	−·064	39·60	28·826	−·025	37·31	28·842
·774	57·74	·471	39·16	48·45	·803	−·029	50·32	·768	+·006	48·07	·801
·730	72·86	·534	49·84	61·35	·691	+·039	58·71	·656	+·074	56·34	·708
Colle di Valdobbia and Alessandria.											
30·046	31·64	22·351	22·69	27·16	30·237	−·191	36·68	30·182	−·136	34·23	30·191
29·958	47·93	·376	29·12	38·53	30·043	−·085	42·91	29·998	−·040	40·67	·021
·822	62·53	·406	39·97	51·25	29·845	−·023	52·50	·801	+·021	50·06	29·846
·759	78·58	·507	52·16	65·37	·725	+·034	63·34	·685	+·074	61·16	·754

In order to deduce from these observations the most probable value of the mean temperature of the air column I proceeded as follows:

I multiplied the half sum of the temperatures observed at the first and second stations by the difference of elevation between the two stations; I multiplied the half sum of the temperatures observed at the second and third stations by their difference of elevation. I proceeded in like manner with the third and fourth stations, and also with the fourth and fifth. I then divided the sum of these four products by the difference of level between the first and fifth stations and regarded the quotient as representing the mean temperature of the air column. The difference between this result and the half sum of the temperatures at the first and fifth stations is given in column seventh, where the + sign indicates that the mean temperature of the air column is greater than the half sum of the temperatures at the upper and lower stations. I proceeded in the same manner with the observations at 4.35 P. M. and 11 P. M.

TABLE IV.—*Change of temperature with elevation.*

7·35 A. M.						4·35 P. M.						11 P. M.					
285	5553	4058	2898	134	Diff.	6285	5553	4058	2898	134	Diff.	6285	5553	4058	2898	134	
4	38·5	45	51	61·6	+1°·0	42	48·5	55·5	63·5	74·0	+2°·1	37	41·5	48	55	64·2	+
0	32	35·5	43·5	56·0	−1·5	35	42·5	47	56	60·4	+3·6	29	32·5	39	39·5	54·2	−
2	34·5	40	46	50·6	+1·5	38	46	53	57	57·2	+5·5	37	41·5	43·5	44	51·8	+
8	40	45·5	47·5	48·8	+2·0	47	50	57	61	55·4	+4·9	47	49	53	57	56·6	+
0	42	46	53	54·4	+1·8	42	44·5	49	58	57·2	+2·9	37	40·5	45	47	52·6	+
1	45	49·5	54·5	55·6	+2·8	43	50	55	61	59·6	+5·0	38	40·5	45	47	53·8	+
6	37·5	44·5	51·5	62·0	−1·0	35	37·5	43	49	54·8	+1·2	35	37	41	48	57·6	−
3	36	42·5	48·5	56·2	+1·1	40	50·5	56	60·5	66·6	+4·5	36	40·5	46	46	54·4	+
0	44	49·5	50	59·4	+0·6	48	56·5	64·5	69·5	71·8	+5·4	41	44·5	48	47	61·6	−
4	50	56	58	60·6	+3·6	53	62	70	72	69·8	+6·7	47	50	57	61·5	61·0	+
8	51	56	59·5	63·0	+1·8	45	47	54	63	79·2	−1·4	39	40	45·5	52·5	63·6	−
2	35·5	40·5	47	64·0	−1·6	33	37	44	51·5	67·6	−0·6	32	36	41	41	54·2	−
8	42·5	47	52	62·4	+0·5	44	50	61	61	67·8	+3·6	38	40·5	45	46	56·2	−
7	44	49	48·5	60·6	+1·0	44	47·5	59	58	62·2	+3·3	41	45	46	44	59·0	−
43	48·5	52·5	57	61·2	+2·5	47	50·5	58	64	70·6	+1·9	46	49·5	54·5	53	62·6	+
49	52·5	58	65	71·6	+1·4	51	56	64	69	77·8	+2·1	42	43	48	52·5	69·2	−
37	39	44	50	64·2	−1·5	37	45·5	54	56	72·4	+1·5	30	33	41	45	58·8	−
34	38	42	47	61·6	−1·0	44	52	58·5	64	66·6	+4·7	44	48	55·5	53·5	64·2	+
45	48	56	62	67·0	+2·3	53	58	67	68·5	71·0	+3·9	53	56	63	66	63·6	+
46	47	53·5	60·5	69·0	0·0	49	49	56	63·5	79·8	−2·4	36	36	43·5	49	62·4	−
31	33·5	42	50	62·2	0·0	34	34·5	42	49·5	64·2	−1·6	32	33	39·5	40	53·6	−
34	35	40	46	60·0	−1·9	36	39	46	56	67·4	+0·4	34	35·5	42	40	54·6	−
41	45	47	52	64·8	−1·0	46	54·5	60	64·5	70·4	+3·7	44	43	49	48	59·8	−
45	49·5	57	58	65·8	+1·8	48	55	63	63·5	74·0	+2·3	45	48	54	50	62·0	−
50	53·5	59	62·5	68·4	+1·5	55	62·5	71·5	73	77·6	+4·4	48	51	58	55	64·0	+
56	57·5	59	64	71·2	−0·8	57	65·5	73	75·5	80·4	+4·4	50	51·5	59	56·5	70·6	−
52	54·5	58	63	71·8	−0·2	55	65	72	74	78·6	+5·0	51	54	61	61	71·0	+
52	54	58	63	75·8	−1·4	51	57	63	71·5	78·8	+2·5	47	48	54·5	54	66·6	−
53	56	57	65	72·4	−1·8	58	66·5	71	78	77·8	+5·2	54	56·5	63·5	65	68·6	+
53	55·5	62	69	69·8	+2·8	55	56·5	64	70·5	74·6	+1·7	52	53·5	60·5	65	69·8	+

The average of the differences shown in this table (paying attention to the algebraic signs) for 7.35 A. M. is +0°·54, for 4.35 P. M. it is +2°·88 and for 11 P. M. it is +0°·05. In six cases we find differences as great as five degrees. These large differences occur only at 4.35 P. M. and appear to depend mainly upon other circumstances than the height of the barometer. The average of all the differences when the barometer on Mt. Washington was considerably below the mean is +0°·84; and the average of all the differences when the barometer was considerably above the mean is +1°·22, showing a difference of only 0°·38 depending upon the height of the barometer on Mt. Washington, and this is only five per cent of the difference shown in table III for the warmest season of the year. We hence conclude that the error arising from assuming that the mean temperature of the air column is equal to the half sum of the temperatures at the upper and lower stations, is quite inappreciable if the observations embrace a considerable period of time and are made at all hours of the day. The observations made on Mt. Washington in May, 1873, and those made in May, 1872, and published in the Report of the Chief Signal Officer for 1872 lead to similar conclusions.

I consider it to be proved that the differences shown in table III between the pressures observed at sea-level and the Mt. Washington observations reduced to sea-level by the tables of Laplace, or Plantamour or Ferrel, are not due in any considerable degree to an error in the assumed temperature of the air column. The question then remains unanswered, what is the cause of these discrepancies? In my fifteenth paper, on page 6 I have given a table of forty cases in which the observed reduction of the Mt. Washington observations to sea-level was 0·30 inch greater than that given by the formula of Laplace. These forty cases are derived from 3285 observations, viz: three daily observations for a period of 36 months, and therefore constitute but little more than one per cent of the entire number of observations. They represent the cases in which the cause or causes which gave rise to the anomalies shown in table III acted with their greatest energy, and they are therefore well adapted to indicate what this cause was. These cases are enumerated in table V, and I have endeavored to free them from certain errors which may have affected the results as published in my fifteenth paper. In each case I have deduced the pressure and temperature at sea level from the observations at Burlington and Portland by the formula $\frac{1}{5}(2B+3P)$, and the results are given in columns three and four. The four succeeding columns are obtained in the manner explained in my fifteenth paper, and the discrepancies are shown in the ninth column under the heading O−C. It will be perceived that these numbers differ a little from the numbers in my fifteenth paper. The average of the differences given in that paper was 0·36 inch, and the average of the differences in column ninth of table V is 0·35 inch, a change which is unexpectedly small.

BLE V.—*Cases in which the reduction to sea-level was unusually great.*

Date.	Sea-level.		Mt. Wash'n.		mean temp.	Lapl'e reduc.	O—C	Bar. by isobars.	O—C	Wind. Direction and velocity.
	Bar.	Therm.	Bar.	Ther.						
1872.										
ov. 7.3	29·26	40°·4	22·78	20°	30°·2	28·98	+·28	29·24	+·26	SE. 4; SW. 38; NW. 65.
8.1	·33	41·6	·80	21	31·3	·99	·34	·32	·33	NW. 48.
8.2	·44	46·8	·96	22	34·4	29·15	·29	·40	·25	N. 65.
9.1	·77	40·6	23·12	19	29·8	·42	·35	·71	·29	NW. 58.
9.2	·88	39·8	·24	20	29·9	·57	·31	·85	·28	W. 78.
29.2	·72	32·6	22·89	13	22·8	·24	·48	·62	·38	NE. 22; SW. 35.
30.1	·45	15·8	·63	5	10·4	·12	·33	·42	·30	NE. 45.
30.3	·63	16·2	·73	3	9·6	·26	·37	·60	·34	W. 48.
ec. 1.1	·84	20·6	·85	4	12·3	·37	·47	·81	·44	N. 52.
3.2	·80	36·0	23·14	17	26·5	·50	·30	·75	·25	SE 60.
4.1	30·01	30·2	·24	14	22·1	·70	·31	·96	·26	SE. 42; W. 58.
10.1	29·61	11·8	22·78	3	7·4	·36	·25	·60	·24	SE. 16; W. 59.
15.2	·92	30·4	23·12	11	20·7	·57	·35	·96	·39	NW. 23; N. 28; N. 68.
22.2	30·17	6·6	·05	— 9	— 1·2	·86	·31	30·18	·32	SW. 65; W. 35; W. 43.
24.3	·48	— 8·8	·05	—16	—12·4	·07	·41	·50	·43	[23·2 SE. 32]; W. 44.
28.1	29·95	— 1·8	22·75	—20	—10·9	·66	·29	29·93	·27	NE. 60.
1873.										
n. 6.2	30·08	25·0	23·14	6	15·5	·68	·40	30·04	·36	S. 60; W. 32; W. 60.
11.3	·15	8·2	·06	—11	— 1·4	·88	·27	·17	·29	[9·2 SW. 36]; N. 76.
29.1	·22	3·4	·10	— 5	— 0·8	·92	·30	·25	·33	SW. 18; W. 28; W. 54.
b. 10.1	·10	0·0	22·96	— 4	— 2·0	·76	·34	·16	·40	[7·3 S. 34]; NW. 77.
10.2	·07	7·6	23·01	— 5	1·3	·77	·30	·09	·32	NW. 103.
r. 16.2	29·43	33·0	22·78	11	22·0	·11	·32	29·42	·31	S. 38; SW. 52; W. 28.
16.3	·60	27·6	·74	7	17·3	·14	·46	·58	·44	NW. 56.
17.1	·79	25·0	·87	4	14·5	·35	·44	·76	·41	W. 56.
17.2	·94	29·4	23·15	6	17·7	·66	·28	·94	·28	NW. 25.
24.1	·96	14·6	22·92	3	8·8	·52	·44	·97	·45	[21·1 SE. 50]; W. 48.
c. 10.1	30·09	33·0	23·33	15	24·0	·78	·31	30·06	·28	[7·3 calm]; NW. 62.
1874.										
r. 30.2	29·38	38·2	22·67	8	23·1	28·96	·42	29·36	·40	[29·1 E. 35]; NW. 130.
30.3	·41	37·2	·72	10	23·6	29·01	·40	·39	·38	NW. 115.
c. 29.2	·88	26·6	23·02	— 3	11·8	·59	·29	·89	·30	[27·2 N. 20]; NW. 80.
30.2	30·21	10·8	·01	—20	— 4·6	·88	·33	30·20	·32	NW. 98.
1875.										
n. 9.3	29·94	9·4	22·70	—26	— 8·3	·54	·40	29·96	·42	SW. 73; SW. 50; NW. 100
14.1	·78	24·6	·91	0	12·3	·44	·34	·79	·35	SW. 60; NW. 70.
14.3	·94	12·6	·82	—20	— 3·7	·61	·33	·95	·34	NW.
15.1	30·11	2·6	·71	—33	—15·2	·69	·42	30·12	·43	NW.
15.2	·17	5·4	·95	—25	— 9·8	·90	·27	·21	·31	NW.
15.3	·21	— 0·2	23·00	—14	— 7·1	·91	·30	·21	·30	NW.
17.1	·17	2·0	22·91	—24	—11·0	·86	·31	·22	·36	NW.
25.2	29·82	26·6	·93	0	13·3	·45	·37	29·87	·42	[24·2 S. 60]; NW. 80.
26.2	30·06	15·2	·95	—15	0·1	·71	·35	30·11	·40	NW. 94.

In some cases, an appreciable error may arise from assuming that the pressure at sea-level under Mt. Washington is given by the formula $\frac{1}{5}(2B+3P)$ and a more accurate value may be derived from the isobars drawn to represent all the observations in the vicinity of Mt. Washington. Column tenth shows the height of the barometer at sea-level under Mt. Washington obtained by this method. These numbers were generally obtained from the isobars drawn on the Signal Service maps, but in a few of the cases I have made a slight change in the position of the isobars when the curves on the Signal Service maps did not appear to have been drawn with sufficient care. Column eleventh shows the differences between the numbers in columns three and ten. The average of the numbers in column eleventh is 0·34 inch. The error in the assumed mean temperature of the air column produces a small effect, but by none of the preceding refinements are the discrepancies to be explained materially changed.

In order to have a graphic representation of the relation of these quantities to the state of the barometer, I have drawn the curves representing the barometric observations on Mt. Washington, and also the curves of pressure at sea-level, for the entire period of the three years which comprehend the observations in tables I and II; and on these curves I have indicated by small black circles, the position of each of the forty cases included in table V. The accompanying chart, plate I, shows such portion of these curves as embrace the cases enumerated. The spaces between the vertical lines represent intervals of eigh hours, and the spaces between the horizontal lines represe tenths of an inch of barometric pressure.

From an inspection of these curves we see that each of the forty cases occurred during the prevalence of an area of lo pressure about Mt. Washington. Twenty-one of them we coincident with the lowest pressure observed during the prev lence of the low area; nine occurred eight hours after the lowe recorded pressure; and five others followed soon after th preceding, when the barometer on Mt. Washington was risin but had not yet reached the point of mean pressure. Of th remaining five cases, two occurred at a secondary minimum that is when there was a smaller minimum included within large area of depression; two other cases preceded by eigh hours the minimum on Mt. Washington, but one of them wa eight hours and the other sixteen hours later than the minimum at sea-level, and the remaining case coincided with slight secondary minimum.

Were these cases of low pressure on Mt. Washington accompanied by a cyclonic movement of the winds? In order to decide this question I have examined the direction and veloc-

f the winds on Mt. Washington not only at the dates of
orty cases in table V, but also at several of the preceding
rvations, and the principal results are exhibited in a con-
ed form in the last column of table V. When only one wind
tion is given, it is to be understood as corresponding to the
in column second. When two wind directions are given,
irst corresponds to a date eight hours previous to that in
mn second; when three wind directions are given, the first
sponds to a date sixteen hours previous to that in column
nd, with the exception of the cases in which the direction
e wind is included in brackets. In these cases the date of
bservation immediately precedes the wind's direction. The
cases shown in table V correspond to twenty-one differ-
reas of low pressure, as was indicated in my fifteenth paper.
of these storm areas began with a N.E. wind on Mt.
hington; one began with an E. wind; five began with a
wind; four with a S. wind; and six with a S.W. wind.
of the remaining cases was preceded by a calm, and one of
e which began with a S.W. wind was also preceded by a
. In the two remaining cases, the wind, as reported in the
aily observations, blew continually from the W., N.W. or
but its velocity at one of the early observations was consid-
ly less than at the observations immediately preceding and
wing.

he twelve storms which began with a wind from the N.E.—
S.E—or S. are regarded as unquestionably cyclonic; and
six which began with a S.W. wind are regarded as probably
onic. In the three remaining cases, one of which began with
m, and the other two with a comparatively feeble wind
the N. or N.W. the evidence of a cyclonic motion is
tisfactory unless it is confirmed by other circumstances.
ve endeavored to obtain additional evidence bearing upon
question, from observations of the upper clouds made at
hboring stations on the E. and S.E. sides of Mt. Wash-
on; but during the periods in question the upper clouds
generally concealed from view by the lower clouds. The
wing are the only observations I have been able to find
ch bear directly upon this question.

	Wind.	Upper clouds.
1872. Nov. 7.2, Portland, Me..	N.W. 18	S.
1872. Nov. 30.2, Portland, Me..	S.W. 18	S.
1873. Feb. 8.1, Portland, Me..	S.W. 12	N.E.
1873. Mar. 17.2, Portland, Me..	N.W. 18	N.E.
1873. Mar. 18.1, Portland. Me..	S.W. 8	S.E
1873. Dec. 9.2, Portland, Me..	S.W. 8	E.
1875. Jan. 14.2, Eastport, Me..	N. 22	E.

There can be no doubt that the upper clouds here reported had a considerable elevation, which was probably at least equal to that of Mt. Washington, and they indicate a cyclonic motion of the winds about a center but a few miles E. of Mt. Washington. I think then we may safely conclude that in a majority of the cases enumerated in table V, the fall of the barometer on Mt. Washington was due to a cyclonic movement of the winds which prevailed at that elevation. In the remaining cases the observations seem to leave it doubtful whether the fall of the barometer on Mt. Washington was due to a cyclonic movement of the winds which extended to the height of 6000 feet, or was due to a cyclonic movement of the winds which was confined to a lower stratum of the atmosphere. From Plate II accompanying my tenth paper we see that the fluctuations of the barometer on the top of Mt. Washington are often quite unlike those at the base (which is 3387 feet below the summit, and 2898 feet above sea-level), and the fluctuations are sometimes greater in amount. From the plate accompanying this paper we also see similar differences between the barometric oscillations on Mt. Washington, and those at stations in its vicinity near sea-level. According to theory, the fall of the barometer during a cyclonic storm near sea-level should be to the fall on the top of Mt. Washington (the other elements which affect the result being supposed to be the same), in the ratio of the mean pressures at the two stations, i. e. as 29·98 to 23·63 or nearly as five to four. Hence we see that on the summit of Mt. Washington there are frequently cyclonic movements of the wind which are more violent than those at inferior elevations, and this explains in part the anomalies shown in table V. But these anomalies are partly due to the fact that the barometric minima on Mt. Washington generally occur later than they do at sea-level. In several of my former papers I have dwelt upon this subject, and the same fact is clearly indicated by the accompanying plate. The average date of minimum pressure on Mt. Washington is more than eight hours later than it is at sea-level; and there are frequently secondary minima on Mt. Washington which do not occur at sea-level or only in an inferior degree. Hence it results that when the barometer on Mt. Washington stands at its lowest point, the barometer at sea-level has generally risen above the preceding minimum one or two tenths of an inch, and occasionally four tenths of an inch; and at the time of a secondary minimum on Mt. Washington, the barometer at sea-level may have risen three or four tenths of an inch, or even five tenths of an inch more than it has risen on Mt. Washington. Thus on Jan. 15.1, 1875, when the barometer on Mt. Washington was at its lowest point, the barometer at sea-level had already risen four tenths of an inch: and at the secondary minimum of Dec. 24.3, 1872, the barometer at sea-level had already risen above the preceding minimum a half inch more than the Mt. Washington barometer had risen. A similar case occurred Dec. 30.2, 1874. The discrepancies shown in table V are due partly to the causes here stated, and partly to the violence of the winds on Mt. Washington, for according to theory, the velocity of the wind is the most important factor which determines the depression of the barometer in a great storm.

The excess of the barometric pressure at sea-level above the Mt. Washington observations reduced to sea-level as shown by table III in the case of barometric minima, is ascribed to the same causes.

The differences between the observed and computed reduction to sea-level in the case of barometric maxima shown in table III are explained in a somewhat similar manner. From the accompanying plate, as well as from the plate accompanying my tenth paper, it is seen that generally the date of a barometric maximum is not as distinctly marked as that of a barometric minimum, but the average date of maximum pressure on Mt. Washington is more than eight hours later than it is at sea-level; and when the barometer on Mt. Washington stands at its highest point, the barometer at sea-level has frequently fallen below the preceding maximum, a tenth of an inch or even more.

If we attempt to represent the reduction of the Mt. Washington observations to sea-level by the Laplace formula with modified coefficients, we find that the high pressures require a larger value of the pressure coefficient than the low pressures. Also that the low temperatures require a larger value of the temperature coefficient than the high temperatures. It is not possible therefore to find values for these coefficients which shall represent the observed reduction for all pressures and temperatures. I have sought to obtain values which shall best represent all the observations, and in doing this I have given the observations made near the time of barometric maxima, twice the weight of those made near the time of barometric minima, for the reason that in the former case the winds are more feeble, and the atmosphere probably approaches nearer to the condition of statical equilibrium. With this assumption I have found that the value of the pressure coefficient which best represents the Mt. Washington observations is 60372, and that of the temperature coefficient is $\frac{1}{982}$; indicating that the pressure coefficient employed by Laplace (60158·6) is too small.

I next undertook a similar comparison of the observations on Pike's Peak and Denver. Table VI shows the principal barometric minima on Pike's Peak during a period of three

TABLE VI.—*Barometric minima on Pike's Peak.*

No.	Date.	Denver.		Pike's Peak.		Mean temp.
		Bar.	Therm.	Bar.	Ther.	
	1873.					
1	Nov22.1	24·56	29	17·43	12	20°·5
2	22.3	·92	32	·46	10	21·0
3	27.3	·68	22	·56	9	15·5
4	28.2	·62	48	·26	14	31·0
5	Dec. 2.2	·41	20	·13	5	12·5
6	3.1	·59	− 2	16·97	−21	−11·5
7	3.3	·57	3	17·03	−23	−10·0
8	7.3	·49	28	·26	6	17·0
9	11.2	·54	26	·27	8	17·0
	1874.					
10	Jan. 3.2	·49	19	·11	6	12·5
11	21.2	·47	24	·13	− 1	11·5
12	22.3	·51	19	·11	−16	1·5
13	Feb 12.2	·17	31	16·99	1	16·0
14	21.2	·74	14	17·13	−12	1·0
15	22.1	·72	2	·11	−18	− 8·0
16	24.1	·83	− 6	·16	−14	−10·0
17	Mar. 3.1	·44	29	·14	3	16·0
18	6.1	·53	20	·17	−14	3·0
19	16.1	·23	31	·16	− 3	14·0
20	Apr. 4.2	·56	42	·39	10	26·0
21	12.2	·55	45	·37	11	28·0
22	13.1	·46	42	·38	4	23·0
23	16.1	·84	25	·40	− 5	10·0
24	May 2.1	·49	42	·29	− 1	20·5
25	9.2	·22	56	·25	11	33·5
26	11.2	·78	62	·52	20	41·0
27	Jun 10.1	·79	49	·71	22	35·5
28	Au. 10.1	·67	62	·81	30	46·0
29	Sep.18.1	·76	49	·67	19	34·0
30	Oct. 24.1	·45	48	·42	10	29·0
31	25.1	·76	35	·57	13	24·0
32	27.3	·54	46	·42	8	27·0
33	Nov. 4.1	·53	42	·40	5	23·5
34	7.1	·44	43	·32	3	23·0
35	22.1	·20	37	·16	0	18·5
36	23.1	·64	30	·46	− 1	14·5
37	27.1	·80	22	·47	1	11·5
38	Dec 15.2	·47	42	·35	7	24·5
39	21.1	·67	14	·27	− 6	4·0
40	23.1	·86	14	·33	−13	0·5
41	27.1	·46	11	·16	− 7	2·0
42	28.1	·59	9	·24	− 9	0·0
	1875.					
43	Jan. 4.3	·73	8	·15	− 6	1·0
44	6.2	·51	15	·17	− 7	4·0
45	8.1	·80	−10	·24	− 2	− 6·0
46	12.2	·64	− 9	·06	− 2	− 5·5
	1877.					
47	Jan 11.2	·73	10	·27	9	9.5
48	14.3	·28	32	·21	2	17·0
	1877.					
49	Jan 15.2	24·64	4	17·21	0	
50	21.2	·59	18	·31	1	
51	Feb. 7.1	·72	24	·50	− 2	
52	Mar. 2.2	·21	46	·25	13	
53	8.1	·53	32	·25	− 8	
54	31.1	·23	42	·17	− 3	
55	Apr21.1	·37	50	·30	5	
56	22.1	·59	36	·34	2	
57	26.2	·68	32	·37	0	
58	May 5.1	·54	38	·42	7	
59	18.1	·31	50	·39	11	
60	31.1	·33	51	·35	8	
61	June 7.2	·55	49	·57	23	
62	8.1	·89	42	·61	10	
63	Jul. 26.3	·62	71	·87	33	
64	Sep.13.2	·57	74	·75	32	
65	14.1	·68	53	·69	12	
66	Oct. 13.2	·58	45	·56	27	
67	17.3	·81	49	·62	13	
68	27.3	·56	32	·40	8	
69	Nov. 4.1	·56	28	·45	4	
70	7.1	·57	36	·40	0	
71	13.1	·48	33	·51	8	
72	28.2	·70	21	·27	−18	
73	Dec. 3.2	·34	41	·26	4	
74	4.1	·63	24	·25	−11	
75	5.1	·92	18	·41	−20	−
76	26.3	·66	27	·32	− 7	
	1878.					
77	Jan. 3.1	·59	7	·32	−11	−
78	11.1	·40	33	·38	5	
79	29.1	·68	35	·44	− 6	
80	Feb. 5.1	·29	35	·32	3	
81	8.1	·54	29	·29	− 7	
82	14.1	·44	30	·29	− 5	
83	21.1	·54	30	·37	− 2	
84	Mar. 1.1	·44	34	·38	6	
85	8.1	·16	28	16·99	−18	
86	27.1	·42	36	17·38	10	
87	29.1	·48	31	·35	5	
88	Apr. 9.1	·48	28	·24	− 4	
89	15.1	·33	39	·29	3	
90	17.1	·16	41	·09	− 6	
91	May 2.1	·67	44	·56	10	
92	7.1	·73	40	·55	12	
93	18.1	·49	39	·38	6	
94	Jun 16.1	·76	56	·79	28	
95	July 5.1	·73	63	·91	35	
96	Sep.19.1	·74	51	·75	21	
97	30.1	·46	46	·57	20	

TABLE VII.—*Barometric maxima on Pike's Peak.*

	Denver.		Pike's Peak.		Mean temp.	No.	Date.	Denver.		Pike's Peak.		Mean temp.
	Bar.	Therm.	Bar.	Ther.				Bar.	Therm.	Bar.	Ther.	
							1877.					
.1	24·80	33	17·89	14	23°·5	51	Mar 25.3	24·81	52	17·84	17	34°·5
.3	25·11	58	18·05	30	44	52	26.3	24·74	57	17·81	21	39
.2	24·88	66	17·91	26	46	53	Apr. 5.3	24·66	56	17·69	14	35
.3	25·00	10	17·97	2	6	54	23.3	24·96	37	17·69	10	23·5
.3	24·95	26	17·91	13	19·5	55	M'y 24.1	24·87	53	17·88	22	37·5
.3	24·99	22	17·86	12	17	56	27.1	24·78	51	17·91	25	38
						57	Jun 16.3	24·77	73	18·03	32	52·5
.2	24·85	37	17·82	14	25·5	58	21.3	24·83	69	18·09	33	51
.3	25·13	27	17·88	2	14·5	59	July 5.1	24·92	65	18·17	39	52
.2	24·92	51	17·85	18	34·5	60	9.2	24·94	83	18·14	39	61
.3	24·94	54	17·81	11	32·5	61	Au. 10.3	24·96	70	18·15	39	54·5
.1	24·99	10	17·72	4	7	62	29.1	24·94	57	18·17	40	48·5
.2	24·64	53	17·68	16	34·5	63	Sept. 1.1	25·00	55	18·12	35	45
.2	24 80	32	17·68	12	22	64	7.1	24·90	58	18 05	29	43·5
.3	24·85	30	17·76	3	16·5	65	10.1	24·89	53	18·05	39	46
.3	24·92	45	17·77	9	27	66	20.1	24·90	47	18·05	30	38·5
.3	25·06	36	17·79	16	26	67	Oct. 7.3	24·88	50	17·92	21	35·5
.2	24·80	56	17·77	15	35·5	68	9.2	24·87	68	17·98	31	49·5
.2	24·91	55	17·74	9	32	69	10.1	24·94	38	18·02	26	32
.2	24·75	70	17·79	21	45·5	70	Nov. 9.3	24·90	36	17·92	18	27
.3	24·92	62	17·96	19	40·5	71	10.2	24·84	54	17·92	22	38
.2	25·01	64	17·93	24	44	72	16.1	24·93	49	17·89	16	32·5
.1	24·92	54	18·03	28	41	73	Dec. 7.3	24·98	30	17·89	14	22
.3	24·88	70	18·00	29	49·5	74	9.3	24·89	37	17·92	20	28·5
.2	24 91	93	18·19	48	70·5	75	10.3	24·89	37	17·98	18	27·5
.2	24·88	84	18·20	54	69	76	12.3	25·13	35	17·96	10	22·5
.3	24·90	81	18·15	41	61		1878.					
.2	24·86	75	18·08	49	62	77	Jan 10.1	24·71	21	17·70	8	14·5
.1	24·82	54	18·03	35	44·5	78	16.1	24·72	17	17·69	5	11
.3	24·99	57	18·09	29	43	79	21.1	24·95	15	17·73	− 4	5·5
.2	24·95	76	18 07	29	52·5	80	27.1	24·74	26	17·63	2	14
.3	25·01	50	18·04	24	37	81	Feb. 4.1	24·72	32	17·70	8	20
.2	24·96	72	18·06	32	52	82	18.1	24·69	39	17·66	12	25·5
.1	24·96	29	17·84	12	20·5	83	26.1	24·77	17	17·69	7	12
.2	24·90	56	17·85	22	39	84	Mar 16.1	24·97	34	17·88	16	25
.1	24·98	47	17·89	15	31	85	21.1	24·90	35	17·88	17	26
.3	24·92	37	17·87	14	25·5	86	24.1	24·86	40	17·89	12	26
.3	25·20	81	17·95	11	21	87	Apr. 5.1	24·72	39	17·77	16	27.5
.2	25·02	61	17·96	18	39·5	88	25.1	24·80	35	17·75	10	22·5
						89	29.1	24·74	43	17·78	22	32·5
.3	24·91	22	17·59	1	11·5	90	May 9.1	25·09	44	17·89	15	29·5
.3	24·72	39	17·53	4	21·5	91	10.1	24·98	37	17·87	14	25·5
.2	24·56	40	17·59	17	28·5	92	24.1	24·89	45	17·88	20	32·5
.3	24·84	15	17·55	− 5	5	93	Jun 15.1	24·99	55	18·02	34	44·5
						94	19.1	24·93	55	18·05	35	45
.2	24·92	46	17·79	9	27·5	95	22.1	24·84	61	18·08	33	47
.1	25·07	0	17·83	7	3·5	96	Jul. 13.1	25·01	67	18·22	38	52·5
.1	25·07	14	17·84	5	9·5	97	21.1	24·94	65	18·14	40	52·5
.3	24·89	33	17·82	13	23	98	Aug. 1.1	24·96	67	18·20	44	55·5
.1	25·00	25	17·84	8	16·5	99	3.1	24·93	63	18·17	48	55·5
.3	25·04	35	17·87	10	22·5	100	24.1	24·95	70	18·17	41	55·5
.3	24·85	60	17·90	23	41·5	101	Sept. 2.1	24·97	60	18·16	36	48
.3	24·88	48	17·84	13	30·5	102	26.1	25·02	39	18·00	27	33

years, and the observations are arranged in the same manner as in table I. Table VII shows the principal barometric maxima on Pike's Peak during a period of three years.

The numbers in each of these tables were divided into four equal groups, and the average of the numbers in each group was taken. The results are given in the first five columns of table III, and the numbers in the other columns were computed in the same manner as has been explained for Mt. Washington.

We see that for barometric minima, the differences between the observed reductions to sea-level and those computed by the Laplace formula are quite small, while for barometric maxima they are quite large; but when the computations are made by Ferrel's tables the average difference between theory and observation is almost exactly the same in both cases, with the exception of the algebraic signs. These results accord with those for Mt. Washington in indicating that the pressure coefficient in the Laplace formula is too small. The value of the pressure coefficient which best represents the Pike's Peak observations is 60357, and that of the temperature coefficient is $\frac{1}{1009}$. For barometric minima, the average difference between the observed reduction and that computed by Ferrel's formula is less than half of that found for the Mt. Washington observations, a result which may be ascribed, at least in part, to the feebler winds which prevail on Pike's Peak.

For barometric maxima, the differences for Pike's Peak computed by Ferrel's formula are greater than for Mt. Washington, and for the lowest temperatures they are more than twice as great. We have found for Mt. Washington, three causes for these discrepancies: 1, an erroneous assumption with regard to the mean temperature of the air column; 2, a retardation in the date of barometric maximum at the upper station; and 3, small changes of pressure at one of the stations which are not felt (or in a less degree) at the other station. I know of no observations which indicate what effect may be ascribed to the first of these causes in the present case, but probably the effect is small. The effect due to the second cause is often quite large. The barometer at Denver (after a maximum) generally begins to fall from eight to sixteen hours sooner than on Pike's Peak, and it sometimes falls a quarter of an inch or more before the descent begins at Pike's Peak. Thus Dec. 13.3, 1873, after an uncommonly high pressure, the barometer at Denver fell ·28 inch before the barometer at Pike's Peak began to fall. Again Jan. 14.1, 1874, the barometer at Denver was at a maximum, from which time it fell for four days uninterruptedly with the exception of two slight reactions, one amounting to ·01 inch and the other to ·04 inch. The barometer at Pike's Peak did not begin to fall until after Jan. 16.1, when the arometer at Denver had already descended ·43 inch. A simar case occurred between April 8 and April 10, 1874. This ause of the discrepancies between the observed and computed eductions, seems to be more efficient for Pike's Peak than for It. Washington. The third cause above mentioned affects the bservations on Pike's Peak, but in general the curve of presure for Pike's Peak is much less jagged than for Denver. he barometer on Pike's Peak frequently remains above its nean height for several days—sometimes a week or ten days—vith only small fluctuations, while during the same period at Denver there have been numerous maxima and minima of considerable magnitude. Thus it sometimes happens that a barometric maximum on Pike's Peak occurs nearly, if not exactly, at the time of a barometric minimum at Denver.

[To be continued.]

ART. II.—*Light of Comparison Stars for Vesta*; by EDWARD C. PICKERING.

IN Professor Harrington's important "Study of Vesta," which appeared in this Journal, III, xxvi, 461, the light of the planet was determined from comparisons with the two stars DM. +22° 2163 and 2164. The observations were made with the wedge photometer, and were accordingly differential, so that the resulting magnitudes of Vesta depend upon the assumed magnitudes of the stars, which were taken from the Durchmusterung. It therefore appeared desirable that the stars should be observed with the large meridian photometer of the Harvard College Observatory, with the object of providing means for the reduction of Professor Harrington's results to absolute measures. The meridian photometer has been described in the Monthly Notices of the R. Astron. Society, xlii, 365.

The following table exhibits the results respectively obtained for the two comparison stars. The first column contains the numbers of the series to which the observations belong, the second the dates, and the third the initials of the observers, E. C. Pickering and O. C. Wendell. The fourth and fifth columns contain residuals expressed in tenths of a magnitude. The mean results, from which these residuals are derived, when corrected for atmospheric absorption, are 9·06 for DM.+22° 2163 and 5·48 for DM.+22° 2164. The fifth observation of DM.+22° 2163 was rejected because it appeared that an error of 30° in reading the graduated circle of the photometer had probably occurred in one of the four comparisons which constitute a complete observation with the meridian photometer. The residual corresponding to the rejected observation is placed in brackets. If the presumed error of 30° is left without correc this residual would become −0·9 instead of −0·2. separate reduction of the four comparisons gives the resi —2·4, 0·0, −0·5, +0·1. Correcting the first reading by 30 residual is reduced to —0·3.

No. of Series.	Date, 1884.	Obs.	Residuals 2163	Residuals 2164
249	March 16	P.	—0·1	0·0
251	March 18	W.	0·0	0·0
252	March 22	P.	0·0	−0·1
254	March 25	W.	+0·1	+0·1
255	March 31	P.	[−0·2]	−0·2
261	April 14	P.	+0·1	+0·2

The corrections to be applied to the DM. magnitudes o stars appear from these observations to be +·28 for DM.+ 2163 and+ ·18 for DM. +22° 2164. From these correc may be derived the formula $M-m=\cdot023m+\cdot058$, in whic denotes the photometric magnitude of Vesta correspondi the magnitude *m* given by Professor Harrington.

In the following table the first column is repeated from fessor Harrington's table in the article above mentioned. second column contains the corresponding magnitudes of V computed for mean opposition, after correction by the for just obtained. By mean opposition is understood, as usual situation in which a planet is in exact opposition to the while both the planet and the Earth are at their mean dista from the Sun. The third column contains the residuals the mean, 6·64, of the corrected magnitudes thus found. last column contains the residuals showing the accordan Professor Harrington's observations of the two comparison Taking the differences between the two columns of his headed 2164 and 2163, we have a series of quantities expr in seconds of time, the mean of which is 20·6; it correspon the photometric difference in magnitude resulting from observations made here with the meridian photometer. photometric difference is 9·06−5·48 = 3·58. These data that in Professor Harrington's observations one second of may be expressed in terms of magnitude by ·174. The column of the table here given accordingly contains the prod by ·174 of the differences between Professor Harrin columns 2164 and 2163, diminished by the photometric ence 3·58. If reduced to the equator, the quantity becomes ·16, which furnishes a determination of the con of reduction required by the particular wedge employed. last line of the table contains the numerical means of quantities in the last three columns. It may be observed in the first and third lines of the table the large residuals i third column are accompanied by large residuals in the column and are therefore partly attributable to errors of observation. In the seventh line from the end of Professor Harrington's table, 5·84 is assumed to be a misprint for 6·84.

Sidereal time of Observation. April, 1883. d.	h.	m.	Magn. of Vesta.	Residuals. Vesta.	Residuals. Stars.
9	XII	17	7·21	+·57	−·24
13	XII	31	6·59	−·05	+·05
	XIV	57	6·17	−·47	−·26
	XV	24	6·39	−·25	−·19
15	XII	38	6·55	−·09	+·02
	XIII	19	6·43	−·21	+·07
	XV	43	6·32	−·32	−·14
16	X	3	6·73	+·09	·00
	XI	55	6·85	+·21	+·03
	XII	26	6·43	−·19	+·14
	XII	55	6·78	+·14	+·11
	XIII	24	6·69	+·05	−·14
	XIII	49	6·79	+·15	−·12
	XIV	18	6·79	+·15	+·05
17	IX	39	6·52	−·12	+·09
	X	11	6·47	−·17	+·12
	X	40	6·48	−·16	+·11
	XI	5	6·75	+·11	−·03
	XI	29	6·51	−·13	+·12
	XI	50	6·52	−·12	+·14
	XII	11	6·61	−·03	+·02
	XII	31	6·62	−·02	−·22
19	XII	41	6·67	+·03	−·02
23	XII	8	6·82	+·18	+·07
	XII	58	6·85	+·21	+·17
26	XI	55	6·91	+·27	−·02
28	XII	27	6·84	+·20	+·03
			6·64	±·17	±·10

The mean result for the magnitude of Vesta, 6·64, may be compared with the results formerly obtained at this Observatory and published in the Astronomische Nachrichten, cii, 151. The value obtained from observations on 12 nights in 1880 was 6·49, and from observations on 10 nights in 1881–2 was 6·45. The differences between these values and that derived from Professor Harrington's observations do not seem large, considering the fact that the two methods of observation were very dissimilar. In measuring large intervals of brightness with the wedge photometer systematic errors may perhaps result from irregularities in the tint of the glass and other causes. On the other hand, the small meridian photometer used in the observations of Vesta was not designed for measuring the light of objects fainter than the sixth magnitude, and even the brightest asteroids were seen in the instrument with some little difficulty.

The magnitude 6·51 found for Vesta in vol. xi of the Annals of this Observatory, page 294, was obtained by an indirect process, and its close agreement with the later results just mentioned is probably accidental.

Harvard College Observatory, Cambridge, Mass., May 19, 1884.

ART. III.—*Mineralogical Notes from the Laboratory of t Geological Survey;* by F. W. CLARKE and T. M. C

THE following analyses of minerals have been exec us in the laboratory of the U. S. Geological Survey, the past few months. Some of them possess more th nary interest, and all have value sufficient to warrant them on record. The only novelty in the methods of has been in the determinations of the alkalies. These c nations were made by a modification of Hempel's pro decomposing silicates by fusion with bismuth oxid account of the process, as improved and used in this tory, will in due time be published.

1. JADE AND PECTOLITE.

Among the Eskimo implements collected by the Signal Service at Point Barrow, Alaska, were a consi number of a material which appeared to be jade. C there were two varieties; one pale apple-green, the oth green; both were highly polished, and exceedingly c and tough. The sp. gr. of the pale green variety wa that of the dark material was 3·012. Analyses (Clark results as follows:

	Pale-green.	Dark-green.
Water	4·09	1·41
Silica	53·94	57·01
Ferrous oxide	*trace.*	6·95
Lime	32·21	12·75
Magnesia	1·43	21·36
Alumina	·58	.42
Soda	8·57	----
	100·82	99·90

The dark-green material is plainly jade, or nephrit analogous in composition to that from the Swiss Lake ings. The light green mineral, on the other hand, a composition with pectolite. It is easily fusible, and short, all the essential properties of pectolite. It is, th a new and interesting variety of that well-known specie

The Eskimo of Point Barrow say that the jade and j minerals used by them come from some point to the e The locality itself, we believe, has not yet been visited ilized men. Whether both minerals are found at th place or not, cannot be stated; but we hope that befo more definite information may be secured.

2. SAUSSURITE.

om a euphotide collected by J. S. Diller, U. S. Geol. Surv., -seven miles north of Pitt River Ferry, Shasta County, ornia. The mineral is nearly white, with a greenish-gray and has a sp. gr. of 3·148. As the rock itself will be de- ed by Mr. Diller, only the analysis of the saussurite need ted here.

alysis, F. W. Clarke.

Ignition	2·42
Silica	42·79
Alumina	29·43
Lime	18·13
Ferrous oxide	3·65
Soda	2·51
Magnesia	1·40
	100·33

3. ALLANITE.

om Sprague's granite quarry, Topsham, Maine. Abund- in slender black prisms, usually rusty upon the surface, h are known to the local quarrymen as "nails."

nalysis, F. W. Clarke.

Ignition	4·13
Silica	34·97
Alumina	12·83
Ferrous oxide	18·11
Manganous oxide	2·82
Cerium, lanthanum and didymium oxides	17·26
Lime	7·21
Magnesia	1·40
	98·73

e ferrous oxide carries with it some ferric oxide. As the sis was made merely for the complete identification of the es, the troublesome separation of the cerium group oxides not considered necessary. The mineral appears to vary derably in different parts of the quarry.

4. DAMOURITE.

o specimens of a micaceous mineral from the topaz local- Stoneham, Maine, collected by Mr. N. H. Perry of South , and sent by him to the National Museum, have been ined and prove to be different forms of damourite.

Subfibrous compact, light grayish green in color, greasy r, associated with albite and topaz.

B. Broadly foliated micaceous, light grayish green, st mother-of-pearl luster, also associated with topaz. Ana (Chatard) as follows:

	A.	B.
Ignition	4·48	4·78
Silica	45·19	45·34
Alumina	33·32	33·96
Ferrous oxide	4·25	3·96
Manganous oxide	0·58	0·51
Lime	*tr.*	0·22
Magnesia	0·36	0·10
Soda	1·57	1·49
Potash	11·06	10·73
	100·81	101·09

5. MARGARITE.

B. From Soapstone Hill, near Gainesville, Ga. Bright tachio green, subfibrous aggregate of extremely minute sc surrounding and radiating from a core of bright rose-| corundum which is in places interlaminated by the marga A very handsome specimen on account of the contrast of c From Mr. Theodore Moreno of Gainesville, Ga. G. = 3 H. = 3·5. Analysis, T. M. Chatard:

Ignition	4·88
Silica	31·72
Alumina	50·03
Ferrous oxide	*tr.*
Lime	11·57
Magnesia	0·12
Alkalies (principally soda)	2·26
	100·58

B. An altered crystal of corundum from Iredell Co., N showing a core of corundum surrounded by a yellowish w semi-micaceous, compact mineral more or less intermixed small needles of black tourmaline. Analysis (Chatard) sl the micaceous mineral to be a margarite similar to tha scribed, by Dr. F. A. Genth, as occurring at Hendrick's I in the same county.

Ignition	5·68
Silica	31·15
Alumina	49·51
Lime	11·13
Magnesia	0·45
Alkalies (mainly soda)	2·74
	100·66

6. CIMOLITE?

Among a collection of Maine minerals received from N. H. Perry of South Paris, were several specimens of tourmaline and albite encrusted with a pink to rose-purple, earthy, alteration product. The color was found to be due to a little manganese, which was not, however, separately estimated. The analysis (Clarke), gave results approaching to those required by the rational formula $AlH_3(SiO_3)_3$, as the subjoined figures show.

	Found.	Theory.
Water	9·53	10·4
Silica	70·06	69·8
Alumina*	17·19	19·8
Soda	2·28	
Magnesia	·80	100·0
	99·86	

It will be observed at once that these results do not agree exactly with those commonly obtained for cimolite. They are too high in silica, and too low in water, and the formula deduced from them is somewhat novel. We are inclined to place the mineral, however, under cimolite, as being nearer to that species than to any other. Possibly the new formula represents the final outcome of an alteration process which ordinary cimolite has only partially undergone. Somewhat similar pink alteration products are not uncommon in the albitic granite veins of Maine and New Hampshire, and some, without analysis, have been supposed to be montmorillonite like that of Branchville, Conn. A more thorough examination of such products is much to be desired. The specimens now reported upon came from Norway, Maine.

7. HALLOYSITE.

Collected by Ensign J. B. Bernadou, at the Detroit Copper Mine, near Mono Lake, California. The specimens consisted of irregular lumps, covered and seamed with a black coating of the oxides of copper and manganese. The color of the pure mineral was white, with a very faint tinge of blue. Analysis by F. W. Clarke.

Water	18·95
Silica	42·91
Alumina	38·13
	99·99

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* Including a little manganese.

8. PROCHLORITE.

A dark-green chlorite collected by Mr. G. P. Merrill on Foundry Run, Georgetown, D. C., may be assigned to the above-named species. The mineral is very dark in color, scaly-crystalline, and occurs in quite fine specimens.

Analysis, F. W. Clarke.

Water	14·43
Silica	25·45
Magnesia	15·04
Alumina	17·88
Ferrous oxide	24·98
Soda	·67
	98·45

The iron was all reckoned as ferrous iron, although a little of it is probably ferric.

9. HALOTRICHITE.

At the headwaters of the Gila River, about forty miles north of Silver City, New Mexico, is a deposit of aluminous sulphates which are said to cover some two thousand acres Among a lot of specimens recently received from this locality was one consisting of white, silky, asbestiform fibers, which were readily soluble in water. The analysis (Clarke) gave results which place the mineral under or near halotrichite.

Water	40·62
Sulphuric acid (SO$_3$),	37·19
Ferrous oxide,	13·59
Alumina	7·27
Insoluble	0·50
	99·17

A very little of the iron, but not enough to estimate, was i the ferric state. The mineral is reported to be abundant.

10. ALUNOGEN.

Associated with the halotrichite at the foregoing locality ar great quantities of alunogen. The specimens received at thi laboratory were crusts of various colors, white, pinkish, ye lowish, brown and drab. Most of them contained sulphates o iron in small quantities; but one sample of pink color, wa free from such impurities.

Analysis, F. W. Clarke.

Water	42·56
Sulphuric acid	34·43
Alumina	15·52
Insoluble	7·62
	100·13

The following minerals from new localities have also come under our observation, and may be properly noted here.

Vivianite from Washington, D. C. Found abundantly in a bed of blue clay, during excavations for the foundation of a building on Connecticut Avenue. The mineral occurs in blue, earthy masses.

Hyalite from Foster's mica mine, near Jefferson, Ashe County, N. C. In very fine stalactitic form, coating the under side of a quartz shelf in a broad granite vein. The specimens are tinted with ferric oxide, and are as fine as any yet noted in this country.

Beryl from Gilmore's mica mine, in Montgomery County, Md., twelve miles north of Washington. Abundant, but not well crystallized, and associated with albite, large plates of muscovite, quartz, garnet and black tourmaline.

Cassiterite from the Brewer Gold Mine, Chesterfield County, S. C. Found in some quantity in the "black sands" of the gold washing, and crystals of ¼″ in diameter have been collected. The larger crystals are dark colored, while the small ones are often pale brown, straw-yellow and even colorless. The latter in microscopic grains.

Washington, April 14, 1884.

ART. IV.—*On the occurrence of Alkalies in Beryl;* by SAMUEL L. PENFIELD.

MY attention was first called to the occurrence of alkalies in beryl, by the detection of cæsium in the qualitative analysis of an unknown silicate from Norway, Maine, resembling in outward appearance a specimen of poorly cleavable feldspar. A quantitative analysis was made in which the presence of beryllium was not suspected, and it was not till the results of the analysis failed to yield any satisfactory formula, that a further examination was made and the mineral was proved to be beryl. In calculating the first analysis the small quantity of alkalies, five per cent in all and more than half cæsium, and the great preponderance of sesquioxides made it probable that the mineral was either impure or that some protoxide was present which the alkalies could be regarded as replacing.

Sections of the mineral when examined with the microscope showed that the material was homogeneous, while beryllium suggested itself as an element which might have been overlooked and weighed with the alumina. As soon as this possibility suggested itself to me, I observed that the specimens in many respects resemble beryl. A more or less perfect basal and a very imperfect prismatic cleavage had previously led me to believe that the mineral was hexagonal and a qualitative analysis proved that beryllium was present in large quantity. The analysis was then repeated, using however better material which had in the mean time come to hand.

After finding alkalies in one beryl it seemed to be of interest to test others from various localities. The result has been to show that, as far as tested, they always contain alkalies, although sometimes only in small quantities. Sodium and lithium were always present, cæsium occasionally, while potassium and rubidium were never detected.

To prove if possible that the alkalies in beryl replace beryllium, as well as to find to what extent they are present, a series of quantitative analyses were made, the results of which are given below. I regret very much that the time at my disposal has been limited, and that I could not first have devoted some time to devising a method for the separation of beryllium and aluminum or for determining the errors which would be involved by a certain definite procedure. I will state here that I shall certainly improve the first opportunity which presents itself for investigating this subject further, and I shall hope to be able to add to the value of this article by giving more correct data as to the percentages of beryllium and aluminum. As the chief interest seemed at first to lie in the detection and determination of the alkalies, I proceeded with the analyses and I will give here the results of them. I add also a full description of the methods employed, so that a proper value may be attached to the beryllium and aluminum determinations.

The mineral was fused with sodium carbonate and the silica separated and weighed according to the usual methods; it was in all cases tested with hydrofluoric acid and the small residue added to the oxides. The beryllium, aluminum and iron were precipitated together with ammonia, filtered and washed, the precipitate dissolved, reprecipitated with ammonia, thoroughly washed and weighed. After weighing, the oxides were dissolved in hydrochloric acid and the solution evaporated on the water bath till the free acid was driven off; the chlorides were then dissolved in a little water, filtered into a flask containing about 125–150 c. c. of a cold saturated solution of ammonium carbonate and some undissolved carbonate, and the slight residue of silica, after washing, weighed, tested as to purity with hydrofluoric acid and added to the first weight of silica. The flask containing the ammonium carbonate precipitate was shaken from time to time, then allowed to stand for twenty-four hours and the alumina filtered and washed with a nearly saturated cold solution of ammonium carbonate. The precipitate of alumina was dissolved in hydrochloric acid, filtered from the filter-paper, evaporated on the water bath to expel the free acid and precipitated again in the same way to separate the beryllium more completely. After the second separation the alumina, together with the small quantity of iron, was dissolved in hydrochloric acid, precipitated with ammonia, filtered and weighed. The ammonium carbonate filtrates from the alumina, containing the beryllium, were evaporated in platinum dishes on the water bath to expel the great excess of ammonium carbonate and the beryllium dissolved in hydrochloric acid precipitated with ammonia, filtered and weighed. Sometimes the two filtrates containing the beryllium were precipitated together, sometimes separately; when so, about one per cent of beryllium was found to be extracted by the second separation. The sum of the weights of the alumina, beryllium and iron oxides after the separation agreed closely with the first weight of total oxides. The alumina and iron oxides were dissolved in hydrochloric acid, and after being converted into sulphates and reduced, the iron was determined by means of permanganate of potash. The error involved in this method of separation of beryllium from aluminum is generally regarded to be that the ammonium carbonate solution containing beryllium is a solvent for aluminum. I therefore worked with small volumes to decrease as much as possible the amount of alumina which would go into solution and repeated the separation. The error thus involved can only be determined by repeating the operation on solutions containing known quantities of beryllium and aluminum, and I hope to be able to make the necessary determinations at some future date.

The small quantity of iron exists probably in both states of oxidation, replacing both aluminum and beryllium. The protoxide was determined separately in one analysis only, (analysis V). Beryl is very hard to decompose, even with strong hydrofluoric acid; it was necessary to use the finest, elutriated powder and then a complete solution of the mineral, for titration with permanganate, could not be obtained. As the very small quantity of iron in the other beryl can affect the results but very slightly, and as two-thirds of the iron in analysis V was found to exist as protoxide, I have calculated it as such in the remaining analyses.

Tests were always made for calcium and magnesium, but in only two analyses could they be detected. Great care was taken in the determination of the alkalies. The mineral was in all cases decomposed by long treatment with pure hydrofluoric acid, the bases being converted into sulphates. From the solution the beryllium oxide and alumina were precipitated with ammonia and the alkalies weighed as sulphates. Care was taken to avoid as much as possible the use of glass and all the evaporations were carried on in platinum. In the last analyses where it was known that the amount of alkalies would be very small, the beryllium oxide and alumina were precipitated in platinum dishes, and the only glass with which the solutions were in contact were the glass funnels used in filtering off the precipitates; care was also taken to use water which had not stood long in wash bottles. The sulphates of the alkalies after weighing were converted into chlorides, and the lithium separated by means of alcohol and ether and weighed as sulphate. The cæsium was precipitated and weighed as cæsium platinic chloride. After weighing it was tested carefully with the spectroscope for potassium and rubidium, but neither could be detected.

The loss by ignition is considerable, as will be seen by the analyses. That water is contained in perceptible quantity can be readily seen by heating the mineral very intensely in a closed glass tube. The loss by ignition does not in all cases represent the water chemically combined in the mineral, because liquid inclusions are readily seen in the beryl from Branchville and may be contained in others. The water reacts neutral or only slightly acid to test papers, (the acid reaction probably due to carbon dioxide). It is not completely given off except by very strong ignition. By strong ignition over a blast lamp in a covered crucible no sublimate collected on the lid of the crucible. The powder usually sinters together to a porous cake and this behavior affords an indication of the presence of alkalies, those containing much alkali sintering together to a firm porous mass, while those containing very little as in analyses VI and VII, left a mass which could be readily crushed to powder between the fingers.

Chlorine, fluorine, boracic and phosphoric acids could not be detected.

The varieties which have been analyzed are the following, arranged according to the amount of alkali which they contain. The specific gravities were taken in water of the ordinary laboratory temperature, on a chemical balance, and are given with the analyses.

I. From Hebron, Maine. The material was taken from a fragment of a very much cracked, colorless crystal imbedded in lepidolite and was given to me by Professor O. D. Allen, who collected it at the locality. Care was necessary in select-ing enough pure and clear material for the analysis. It is interesting in showing that the beryl contains much more cæsium than the lepidolite in which it is imbedded.

II. From Norway, Maine. The material was milk-white, and did not outwardly resemble beryl, the fragments in my possession showing no crystal faces. It was collected by Mr. N. H. Perry of South Paris, Me., and sent to Professor George J. Brush, who kindly gave me the material for analysis.

III. From Branchville, Conn. The material was taken from a fragment of a large crystal of a beautiful pale, sea-green color, much resembling a piece of slightly colored quartz.

IV. From Amelia Court House, Virginia. The material was taken from a large milk-white crystal in the collection of Professor Brush.

V. From Royalston, Mass. From a bluish green crystal, from which pure transparent material could readily be obtained.

VI. From Stoneham, Maine. The material was perfectly transparent and taken from fragments of a crystal of a pale green color furnished by Mr. George F. Kunz, of New York.

VII. From Aduntschilon, Siberia. The transparent crystals of a pale green color were taken from a specimen in the collection of Professor George J. Brush. The specimen was sent to him by Mr. J. von Eichwald, who collected it at the locality.

	I. Hebron, Me.	II. Norway, Me.	III. Branchville, Conn.	IV. Amelia Co., Va.	V. Royalston, Mass.	VI. Stoneham, Me.	VII. Aduntschilon, Siberia.
SiO_2	62·10	64·29	64·74	65·13	65·14	65·20	66·17
Al_2O_3	18·92	18·89	20·13	20·80	19·83	20·25	20·39
					Fe_2O_3 ·44		
FeO	·49	·48	·54	·49	·78	·66	·69
BeO	10·35	10·54	10·26	11·03	11·32	11·46	11·50
Cs_2O	2·92	1·66	----	----	----	----	----
Na_2O	1·82	1·39	1·45	·46	·51	·49	·24
Li_2O	1·17	·84	·72	·13	·05	trace	trace
Ign	2·33	2·44	2·69	2·19	2·04	2·08	1·14
	CaO ·35				MgO ·34		
	100·45	100·53	100·53	100·23	100·45	100·14	100·13
Sp. gr.	——	2·744	2·732	2·685	2·711	2·708	2·676

Below I have given the quotients obtained by dividing the percentages by the molecular weights of the constituents arranged in the same order as the analyses. I have regarded the alkalies as replacing the beryllium in all cases, and they are included with the beryllium in protoxides.

Ratio	I.	II.	III.	IV.	V.	VI.	VII.
SiO_2	1·0350	1·0715	1·0790	1·0855	1·0857	1·0866	1·1028
Al_2O_3	·1837	·1834	·1954	·2019	·1952	·1966	·1980
Protoxide	·4995	·4845	·4653	·4597	·4735	·4755	·4735
Water	·1294	·1355	·1494	·1217	·1133	·1155	·0633

Disregarding the water we should have, according to usually accepted formula for beryl, $Al_2Be_3Si_6O_{18}$, SiO_2 : Al, BeO=6 : 1 : 3. As silica is probably the most accurately de mined of any of the constituents, one-sixth of its quotient be taken as unity and the ratio of the sesquioxides and toxides is as follows:

	I.	II.	III.	IV.	V.	VI.
SiO_2	6·00	6·00	6·00	6·00	6·00	6·00
Al_2O_3	1·06	1·03	1·08	1·11	1·08	1·08
Protoxides	2·90	2·71	2·59	2·54	2·62	2·62

It will be seen that the alumina is in all cases too high the protoxides too low. The latter might indicate that par all of the water is basic, replacing the beryllium, and in all the last analysis there is more than enough water, if calcula as replacing the protoxides, to bring up the ratio to 6 : 1 If the error in the separation of aluminum and beryllium is it is said to be, that the alumina is too low, the excess of t constituent in all the analyses cannot be explained if we acc the present formula.

As regards the water, it certainly cannot be called acciden for it is always present in amounts varying from 1·50 to 2 per cent. It is also given off completely only by very str ignition, as the following table will show, indicating that i very firmly united in the molecule. The table is arranged follows: 1st. Loss by drying for one hour at 100° C. 2d. igniting for fifteen minutes at a faint red heat, so that bottom of the crucible only was red. 3d. By igniting fifteen minutes at a full red heat. 4th. By igniting for fift minutes at the full heat of a ring burner. 5th. By heating five minutes over a blast lamp.

	Loss at 100°	low red	full red	white heat
Hebron, Me.	0·12	0·43	0·84	1·65
Norway, Me.	0·12	0·42	1·37	1·73
		0·42	1·49	1·78
Branchville, Conn.	0·10	0·55	1·54	2·62
Amelia, Virginia	0·10	....	1·58	2·10
Royalston, Mass.	0·00	....	1·54	2·00
Stoneham, Me.	0·08	....	1·68	2·02
Aduntschilon, Siberia	0·06	....	0·82	1·10

With the exception of analyses I and II it will be seen t the ratio of SiO_2 : Al_2O_3 : protoxides is nearly 6 : 1 : 2·5, and th is also in all cases water enough to make the ratio of Si Al_2O_3 : protoxides : H_2O=6 : 1 : 2·5 : ·5 or 12 : 2 : 5 : 1. As we c not disregard the water entirely, this would seem to be a pl sible ratio giving the formula $Al_4Be_5H_2Si_{12}O_{36}$. A compou of the above composition would require the following centages: SiO_2 67·36, Al_2O_3 19·27, BeO 11·69, H_2O 1·68=100

Comparing these percentages with the analyses, remembering that there some beryllium is replaced by alkalies and iron protoxide, we notice that the silica is in all cases too low and the alumina too high, as will be seen best by comparison of the ratios where $SiO_2 : Al_2O_3$ was in all cases near 6 : 1·08. If we regard beryl as a little less acid, containing one less SiO_2 than in the above formula we obtain the formula $Al_4Be_5H_2Si_{11}O_{34}$ equal to $2Al_2(SiO_3)_3$, $5BeSiO_3$, HO_2. This formula, although not so simple as the one at first proposed, agrees much closer with the results of analysis. The percentages corresponding to the formula are SiO_2 65·41, Al_2O_3 20·42, BeO 12·39, H_2O 1·78=100·00. The corresponding ratios in the analyses, taking one-eleventh of the silica as unity, are

	I.	II.	III.	IV.	V.	VI.	VII.
SiO_2	11·00	11·00	11·00	11·00	11·00	11·00	11·00
Al_2O_3	1·95	1·89	1·99	2·04	1·97	1·99	1·97
Protoxides	5·30	4·99	4·74	4·65	4·79	4·81	4·72
H_2O	1·37	1·39	1·51	1·23	1·14	1·16	0·63

These ratios are not quite 11 : 2 : 5 : 1, the reason being perhaps on account of the incomplete separation of the aluminum and beryllium, that the water is in excess may result from a partial loss by ignition due to enclosures or something other than combined water. That water and alkalies are constant constituents of beryl may be further shown by the following water and alkali determinations on five beryls which are at my disposal. The alkalies were in all cases determined by a Smith's fusion on one-half gram each. The chlorides were weighed, without pretensions to exact quantitative work, and tested with the spectroscope. They will serve simply to give an idea of the quantity of alkalies.

	Water.	Weight of chlorides.
Green crystal, Portland, Conn.	2·44	0·0194 NaCl, LiCl.
Pale yellow, Haddam, Conn.	1·97	·0047 NaCl, LiCl.
Pale yellowish green, Delaware Co., Pa.	2·21	·0062 NaCl, LiCl.
Green, Acworth, N. H.	2·05	·0052 NaCl, LiCl, CsCl.
Green, Monroe, Conn.	1·65	·0064 NaCl, LiCl, CsCl.

The results of the investigation prove then, that alkalies are always present, undoubtedly replacing the beryllium; that water is also present and cannot be disregarded in the formula, and that the formula $Al_4Be_5H_2Si_{11}O_{34}$ is the one agreeing best with the analyses.

Alkalies have previously been noticed in beryl by M. B. Levy* who found 0·70 per cent Na_2O in material from Muso, New Granada, and by E. Bechi,† who found 0·88 per cent Cs_2O and 3·31 per cent BeO in material from Elba.

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* Ann. Chim. Phys., III, 53, 5. † Jahrb. Min., 1872, 95.

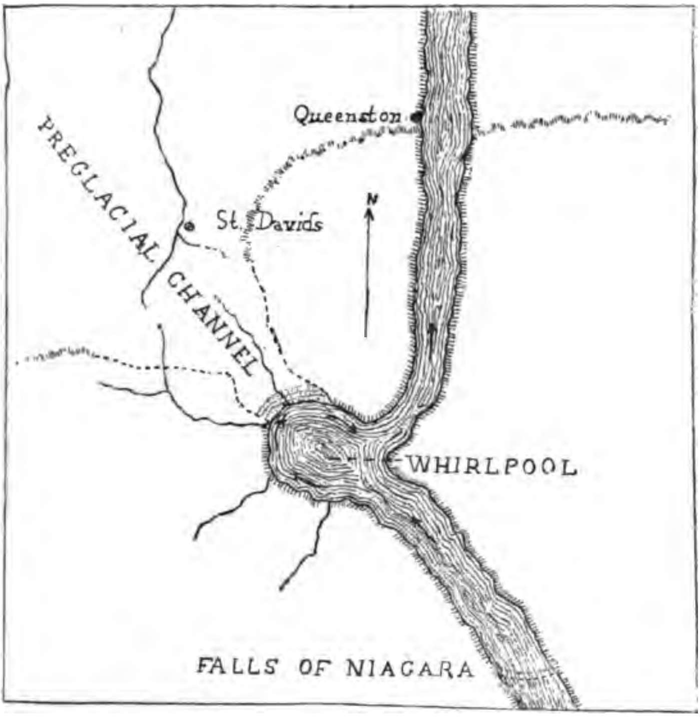
I publish these results, although incomplete in many r spects, because the facts as far as made out are of interest an because I shall not be able to resume the investigation till tl winter of 1884 and '85. I hope, however, to add to this second paper which will serve to clear up some of the doubtfi points. In closing, I take pleasure in expressing my thanks t Professor George J. Brush, for his kindness in providing m with most of the material for this investigation, and to Pr fessor O. D. Allen and Mr. George F. Kunz, for the materi which they furnished.

Sheffield Scientific School, March, 1884.

ART. V.—*The Niagara River and the Glacial Period;* b Professor G. F. WRIGHT.

HAVING recently made a study upon the ground of tl Niagara gorge, I will give as briefly as possible such addition facts to those already well known as my glacial studies special led me to observe. The accompanying plate (prepared to illu trate an article on the subject in the *Bibliotheca Sacra* for Apr 1884) shows at a glance the situation. From the falls to Queen ton the distance is about seven miles, and the gorge continuou averaging about three hundred feet in depth and eight hundre feet in width, though in some places it is thirteen hundred fe wide. At Queenston the river emerges from the gorge and pu sues its way to the lake through a low and level region. Follo ing the rocky escarpment from Queenston to the west, it disa pears after a distances of three miles, near St. David's, under vast deposit of water-worn gravel and sand sloping gradual to the northwest. After passing two or three miles farther the southwest, the rocky escarpment reappears. Thus we ha here what would seem to be an indentation of the preglaci coast-line rather than the opening of a gorge formed by a pr glacial river. This, which clearly is a water deposit of tl Champlain period, continues for some distance, at least, on th high lands as a ridge overlying the till, like the lake ridg of Ohio. Upon going southeast from St. David's towards th whirlpool, one finds these accumulations of sand and grav merging not far from the watershed in a deposit of true till-containing striated stones, and being without stratificatio This continues to the whirlpool, and striated stones were foun within the limits marked on the plate as Preglacial channe where it faces the whirlpool, and twenty-five or thirty fe below the upper surface. The collection of debris, howeve is such as to interfere with observations at a lower level.

A walk from the angle in the escarpment just below the whirlpool to the letter H in the word "Channel" discloses the following succession of phenomena: 1st. For a few rods the bare limestone rock; 2d. After a sudden rise of a few feet, we pass for about a hundred yards over deposits of sand and gravel which were doubtless made in the old bed of the river when the falls were below the whirlpool; 3d. We reach the old bank of the river, which consists of till, and rises fifteen or twenty feet. Till, bearing numerous granitic bowlders, continues for two or three miles of an unknown depth. At the letter H the sand deposits, before described, begin. The small stream flowing through the preglacial channel into the whirlpool nowhere uncovers the rock; hence it may be inferred that there is a buried channel from the whirlpool to St. David's. Still, there is no direct proof of this, as, for a space of two miles, the surface of the country is unbroken and the till from twenty to thirty feet deep. The well to which Sir Charles Lyell indefinitely refers (See Travels in America [First Visit] vol. ii, p. 79) was probably somewhere in the broad opening on the St. David's side, from which little could be inferred. This buried channel where it



emerges from the whirlpool could not have been much over five hundred feet in width, since the first three streams entering into the whirlpool cut through the till to the rock, and descend in cataracts of varying heights; and the distance from the rocky escarpment disclosed by the third stream to the escarpment upon the north side of the whirlpool is not much more than five hundred feet.

That the supposed preglacial channel was not made by a stream comparable in size at all to the present Niagara is probable: *First*, from the shape of the whirlpool recess, which looks more like an enlargement of a gorge which would be naturally made by a united stream that had worn back its channel to a point where two or three branches came together. *Secondly*, the length of the gorge from St. David's,—about six miles,—even if it extended to near the present site of the falls, is entirely too short to represent the work done during preglacial ages by a stream of anything near the size of the Niagara. This follows upon comparison with the enormous amount of preglacial erosion that is everywhere manifest south of the glaciated area, where the preglacial channels have not been buried. Waterfalls may be said to be unknown south of the glaciated area. The trough of the Ohio River and its extension up the Allegheny—for a distance of fifteen hundred miles—has been formed by erosion, such as is going on at Niagara, and may be taken to represent in amount what would have been done by the Niagara River had it flowed in its present channel during preglacial ages. *Thirdly*, we know from direct evidence that the preglacial drainage of Lake Erie was two hundred feet below its present level. This is proved by Professor Newberry's discovery—made known several years ago—that the bottom of the preglacial bed of the Cuyahoga River, opening into the lake at Cleveland, is two hundred feet below its present level. Whether the theory of Professor Spencer (described in Second Geol. Report for Pennsylvania, Q4, p. 359 sq.) concerning the existence of a preglacial outlet from the mouth of Grand River to the head of Lake Ontario be correct or not, is independent of the conclusion that there must have been such an outlet somewhere. Whatever erosion, therefore, was done in preglacial times along the present course of the Niagara must have been accomplished by some small stream draining a limited area.

It seems to me probable that the Niagara River has itself worn the whole of the gorge from Queenston to the falls, with, perhaps, a very little help from preglacial erosion above the whirlpool; though this is a point difficult of absolute determination.

As to the rate of erosion, it now seems that that fixed upon by

Mr. Bakewell in this Journal (see January, 1857, pp. 87–93) was not far from correct; namely, about three feet a year, which would make the time required not over ten thousand or twelve thousand years. These rates of recession have been recently obtained by Dr. Pohlman by comparing the position of the horseshoe fall fixed by Professor Hall's survey of 1841 and the position as determined by the United States Survey in 1875. Dr. Pohlman's paper will soon be published in the Proceedings of the American Association. Mr. James T. Gardiner, of the present New York Survey, informs Professor A. Winchell (see World Life, p. 371) that this rate cannot be far from correct.

The rate of recession for Niagara falls corresponds with inferences drawn from the amount of post-glacial erosion which has taken place in the numerous small streams of Northern Ohio emptying into Lake Erie. For example, there is at Elyria, Ohio, a waterfall in Black River, a small stream about thirty miles in length. The gorge below the falls, which represents the work done by that stream since the Glacial period, is only about sixteen hundred feet in length; and this is about the length of numerous other gorges in Northern Ohio where small streams break over the Waverley sandstone into Lake Erie; and so everywhere the contrast between the amount of erosion accomplished by streams in corresponding strata in post-glacial time and that done in pre-glacial time, such as indicated in the statement just made concerning the Ohio, is perfectly astonishing.

Oberlin, Ohio, May 2.

Art. VI.—*Note on the Discovery of Primordial Fossils in the Town of Stuyvesant, Columbia County, N. Y.*; by S. W. Ford.

On page 406 of Mather's Report on the Geology of the First District of the State of New York, published in 1843, attention is called to certain brecciated and conglomerate limestones occurring in the extreme northwestern portion of Columbia County; and on plate 23 (fig. 8) of the same work, a section is given to illustrate their stratigraphical relations. The rocks are treated of by the author in the chapter devoted to the consideration of the Birdseye and Black River Limestones; and although no fossils are cited from them in proof, the series is regarded as not improbably an inverted one, the older masses occupying the summit of the section. I have recently examined with some care the rocks referred to, and find Mather's section to be substantially correct, except that I do not find any limestone courses in his lower division (*a*).

The strata in question make a conspicuous feature in the topography of the region. Commencing at Schodack Landing, in Rensselaer County, they may be traced southward, with slight interruptions, along the east shore of the Hudson River, for nearly three miles; and for a goodly portion of this distance they are finely displayed. In some instances they constitute bare, natural cliffs, more than a hundred feet in height. They may be studied to good advantage in a number of places, but one of the best points is in the old quarries a short distance north of a line running due eastward from Mr. Peter McCabe's ice-house. At this point I was enabled to obtain the following measured section, which will, I think, be found in the main correct. The strata are enumerated in ascending order, or, as they are met with in passing from the Hudson River Railroad track upward.

SECTION.

1.	Bluish-gray slate	80 feet.
2.	Dark blue, compact limestone, in regular courses, with slight shaly partings	13 "
3.	Reddish quartz rock	1 foot.
4.	Green calcareous slate	6 inches.
5.	Reddish quartz rock	9 "
6.	Green calcareous slate	10 feet.
7.	Even-bedded limestone becoming brecciated at top	5 "
8.	Bluish-gray slate, say	10 "
	Total thickness about	120 feet.

All of the above mentioned beds succeed one another conformably, and all belong, with but little doubt, to one and the same physical group. The fossils obtained from them prove that they belong to the Primordial zone, and to that division of it known as the Lower Potsdam. The paleontological evidence in detail is as follows:

From the limestone deposit near the top of the escarpment (No. 7 of the section) I have thus far obtained the following eleven species: *Palæophychus incipiens*, *Obolella crassa*, *Stenotheca rugosa*, *Hyolithes Americanus*, *H. impar*, *Hyolithellus micans*, *Microdiscus lobatus*, *M. speciosus*, *Conocoryphe trilineata*, *Olenellus asaphoides* and *Fordilla Troyensis* Barrande.

From the dark blue flinty limestones a short distance below (No. 2 of the section) I have obtained but a single species, the *Microdiscus speciosus.*

The slate deposit (No. 1) is likewise fossiliferous, but I have not yet found opportunity to minutely examine it. From a promising layer occurring within a short distance of its visible base, however, I have obtained a specimen which appears to me to be most likely a shell of the Pteropod species *Hyolithellus* *micans.* Now, when we remember that all of the above species, omitting the *Palæophycus incipiens*, are among the commonest species occurring in the Troy Primordial beds; and when we further recall that, as a physical group, the rocks affording them are undistinguishable from those at Troy; it seems to me conclusive proof that the Columbia County beds are simply a southern prolongation of the Troy series. There is certainly no evidence that the slates below limestone deposit No. 2 are of the age of the Hudson River Group; nor is there any evidence, so far as I have been able to discover, that renders it necessary to appeal to an overturned and denuded fold, instead of a fault, to explain the geological structure of the region.

ADDITIONAL NOTE.

Since the above was written, I have examined nearly all of the more southerly exposures of the conglomerate limestones mentioned by Mather, among others those of Great Neuten Hook, near Coxsackie, Merino Mountain, south of Hudson, and that in the neighborhood of Linlithgo in the town of Livingston, Columbia County; also the still more easterly locality which he cites, about four miles east of Rhinebeck, in Dutchess Co. Although my excursion was a somewhat hurried one, and my search for fossils at the several points visited was in the main unsuccessful, the impression made upon my mind by the facts observed, was yet strong that Mather was right in placing all of these rocks in the same great group or zone. The limestones east of Rhinebeck village are more altered than those of Troy and Stuyvesant, but otherwise perfectly resemble them; and moreover they contain traces of fossils, although I was unable to obtain any good specimens. Neverthless, I have scarcely a doubt that they will yet furnish well-characterized examples of the Lower Potsdam fauna. In the course of my studies, I examined nearly all of the exposures of rock along the Hudson River Railroad, and also, to some extent, those further inland beyond the bays and marshes (for the course of the great Appalachian break, though here for the most part a north-and-south one, is, in certain places, grandly undulated), from Schodack Landing to the first railroad tunnel, three miles south of Rhine Cliff station, at which point there is a splendid example of unconformability between the older and newer groups. The rock through which the tunnel passes is almost certainly the Hudson River slate, while the strata which wall against it are in all probability Primordial. The Lower Potsdam group in Canada, below Quebec, has a thickness of at least 2,000 feet, and its thickness is manifestly very great in Eastern New York. In consequence of the generally oblique direction of the folds of the region to the course of the fault referred to, cross-sections of some of the more easterly folds and ridges are constantly appearing in passing southward along the river, and excellent opportunities for their detailed study are thus presented.

Johnstown, N. Y., May 31st, 1884.

ART. VII.—*Notes on some apparently undescribed forms of fres water Infusoria*; by Dr. ALFRED C. STOKES.

IT is desirable but not always possible to ascertain the favo ite position of an infusorian, whether near the surface of tl water or near the bottom. Occasionally inferences can be ma from the relative numbers captured at different depths, and sometimes happens that a glance at the contents of the dige tive vacuoles will indicate the infusorian's relation to dept yet it quite as frequently happens that the food particles are matted together, and the collection so compressed, that a co rect diagnosis is not possible. Instances do occur, howev among the free-swimming types, when the food within the sa code will show whether the animalcules prefer to grovel in t ooze or to float on the sunlit water. To this class belong t following hitherto undescribed forms, all of which were tak from the debris and sediment at the bottom of an aquariu kept without macroscopic animal life solely for the cultivati of the infusorial inhabitants, or collected from the ooze of sh low pools under the open sky.

The food of the new species of Loxodes, which I ha named *Loxodes vorax*, and the creature's favorite position a easily ascertained. Although it does not disdain a mon when it comes convenient, yet its most favored diet is diato and small rhizopods. Of the former any of the freely floatin non-stipitate varieties seem acceptable, frustules being rare absent from the body contents, siliceous valves one-third t infusorian's length often gorging it; in one or two instanc its voracious appetite has led it to capture a frustule so near equal to itself in length that, when attempting to bend its elas body as it seems to take pleasure in doing, one end of the lo diatom has been forced up the pharyngeal passage and out the oral aperture, and when curving in the opposite directic the diatom has been so pressed against the cuticular surfa that the latter has appeared on the point of rupture; if t creature had been spitted it could not have been more effect ally stiffened. The most alluring of the rhizopods is the lit *Trinema enchelys* Leidy. To the writer it has been a source amusement as well as astonishment, to witness Loxodes app ently examine a diatom frustule or a rhizopod shell, nev accepting the one if entirely free from endochrome, nor t latter if empty. I have seen it seize Trinema and make gre efforts to force the shell through the pharynx, but when t morsel proved too large for the expansible passage, reject swim about the neighborhood for a few moments, return a repeat the attempt a second and a third time before final abandoning it.

The Ehrenbergian species of Loxodes, *L. rostratum*, I have not seen, and, so far as I can learn, nothing has been recorded in reference to its food habits. The superficial resemblances between it and *Loxodes vorax*, are sufficient to point out the generic position of the latter if not the life haunts of the former. Their anatomical differences are, however, more conspicuous than their likenesses.

Loxodes vorax, n. sp. (fig. 1) has the elongated and flattened body characteristic of the genus, the dorsal surface being somewhat convex, the ventral flattened and finely striated longitudinally, these delicate furrows bearing the vibratile cilia. The generic diagnosis describes the dorsal region as perfectly smooth, but the present species, under a high degree of amplification has that surface roughened by very minute, irregularly disposed elevations. In other respeots it differs externally from the hitherto single known species in its smaller size, less proportional width, the evenly rounded, somewhat narrowed and attenuated posterior extremity, which is not curved but lies in the plane of the body, in the absence of any angular margin, in the greater breadth of the adoral groove, and in the different arrangement of the dorso-lateral setæ. The latter, in *L. rostratum* Ehr. appear to project horizontally from both sides of the body. With *L. vorax* the sub-horizontal arrangement obtains on the left hand margin where they are usually conspicuous, but beginning at the posterior extremity they leave the right-hand border by a considerable interval, projecting more and more obliquely upward until they stand almost erect, and become visible only on careful focussing.

The adoral groove is much wider than in the type. The usual corneous membrane is borne within it, and is continued into the body to form the tubular pharynx. Its color changes to a chestnut-brown with age, as is the case with the loricæ of certain of the Vaginicolinæ. For this reason the inference is that the chemical composition of the two tissues is identical. Slight experimentation, however, renders this somewhat doubtful. It is well known that the loricæ of Vaginicola and of Pyxicola will for a long time resist the action of caustic potassa in solution. The pharynx and adoral membranous lining of *Loxodes vorax* are rapidly and entirely dissolved by it. So slightly corneous or chitinous is this lining that even a drop of picrocarmine staining fluid destroys it. The whole adoral groove is remarkably flexible and elastic, as indeed is the entire body. The broad furrow can be dilated until it is hood-like or expanded until it is almost a flat surface. Together with the anterior beak it can be bent until it is in contact with the center of the ventral region, or nearer the oral aperture proper. The last is the position when a monad or other equally small and active food particle is to be engulfed. The beak-like front is flexed, the groove-bearing part dilated and, with the aid of the cilia, formed into a trap from which usually the only escape is down the pharynx. The pharynx itself is short and conical, lacking the curvature so conspicuous in the same part of *L. rostratum* Ehr.

The sarcode is not noticeably vacuolar as it is in the Ehrenbergian species. A few scattered lacunæ at times appear posteriorly, but the remarkable trabecular aspect common with *L. rostratum* I have not observed. Neither has a contractile vesicle been positively distinguished; a spherical vacuole is quite constantly present in the posterior body half, but it has not been seen to pulsate.

The nuclei of the type species are described as numerous, scattered throughout the body, and connected together by a funiculus, to which nucleoli are often laterally attached. Such a complicated arrangement I have been unable to detect in *L. vorax*, even after the use of reagents. Here the nucleus seems to be composed of two, separated, nucleolated, spherical nodules, without a connecting funiculus.

The only method of reproduction observed is by obliquely transverse fission. In one instance the partially separated creatures, not content to await the result of the slow action then taking place, deliberately pulled themselves asunder. The body is at times able to adhere to the glass slide or other support, and it here took advantage of that power, clinging to mass of dirt while the separating portion forcibly pulled a long sarcode thread from the parent's body, and continued its effort until the thread snapped. The following description probabl contains the essential specific characters.

Loxodes vorax, n. sp.—Body very flexible and elastic, elongate, flattened, from three and one-half to four times as long as broad, anteriorly somewhat curved to the left-hand and ending in a beak-like apex, posteriorly evenly rounded, somewha tapering and attenuated; adoral groove wide; pharynx tubular, conical and straight; cilia confined to the ventral surface and distributed throughout the fine longitudinal striations, those at the posterior extremity being somewhat more conspicuous, a row of slightly larger cilia bordering the adoral groove; dorsal surface, under high amplification minutely granulate; marginal hispid setæ projecting sub-horizontally from the left-hand margin, somewhat removed from the right-hand dorso-lateral border and becoming more perpendicular as they approach the anterior extremity; parenchyma pale brownish-yellow, seldom conspicuously vacuolar; contractile vesicle (?) single, in the posterior body-half; nucleus double, sub-central, each part spherical and nucleolated, a funiculus not apparent; numerous

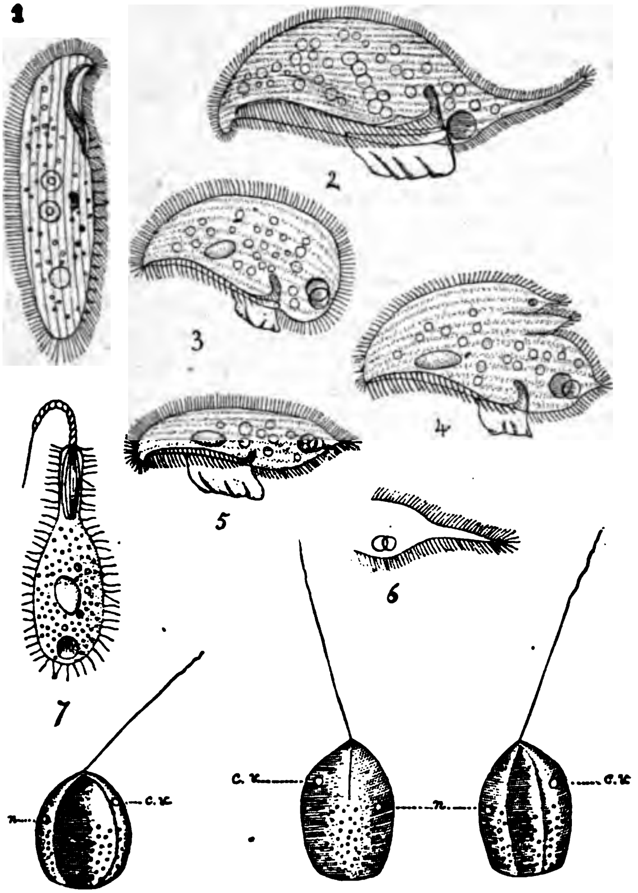


Fig. 1. *Loxodes vorax*, sp. nov. × 300.
Fig. 2. *Apgaria undulans*, gen. et sp. nov. × 380.
Fig. 3. *Apgaria ovata*, sp. nov. × 200. The tail-like prolongation retracted.
Fig. 4. *Apgaria ovata* undergoing longitudinal reproductive fission.
Fig. 5. *Apgaria elongata*, sp. nov. Tail-like prolongation partially retracted. × 275.
Fig. 6. The same with extended tail in outline.
Fig. 7. *Ileonema dispar*. gen. et sp. nov. × 220.
Fig. 8. *Solenotus apocamptus*, gen. et sp. nov. × 1750. Ventral aspect, showing short flagellum.
Fig. 9. *Solenotus apocamptus*, sp. nov. × 1750. Dorsal aspect, showing longitudinal furrow.
Fig. 10. *Solenotus orbicularis*, sp. nov. × 1320. Dorsal aspect.

small refringent corpuscles scattered throughout the body; anal aperture dorsally located, at a short distance in advance of the posterior extremity. Length of body $\frac{1}{180}$ to $\frac{1}{200}$ inch. Habitat—Standing water, chiefly among the decaying debris on the bottom.

Another infusorian, but a member of the *Ciliata-Heterotricha* whose appearance is attractive and its motions graceful, I have taken in small numbers from the debris at the bottom of the aquarium referred to. Its movements are not rapid, consisting chiefly of a steady progression by swimming usually on the right-hand side, or by rotation upon its longitudinal axis. There is, so far as I am aware, no infusorial genus capable of receiving it; I therefore take pleasure in naming it in honor of my learned friend, Mr. Austin C. Apgar, Professor of Zoology in the New Jersey State Normal School.

Apgaria, gen. nov.—Body irregularly ovate, more or less flattened or lamellate, entirely ciliate, soft, flexible, transparent and somewhat changeable in form; the anterior extremity slightly curved toward the left-hand border, and terminating in a more or less beak-like apex; the posterior extremity with a retractile tail-like prolongation; the right-hand body-margin convex, the left-hand border somewhat sigmoid and bearing an elongate-ovate groove or depression extending backward and obliquely inward, the oral aperture being at its posterior widest and deepest part; pharynx tubular, anteriorly curved, expansile and ciliated; the left-hand edge of the peristome field bearing a single row of long vibratile adoral cilia continued around the mouth and into the pharynx, the basal portion of the right-hand margin occupied by a conspicuous, lamellate, undulating membrane; cuticular cilia fine, clothing the longitudinal surface furrows; nucleus moniliform or rounded, subcentrally located; contractile vesicle single or double, posteriorly placed; anal aperture posterior, near the pulsating vacuole.

Apgaria undulans, sp. nov.—(fig. 2).—Body leaf-like and lamellate, longitudinally furrowed, the length twice to two and one-half times the breadth, transparent and irregularly vacuolar, a large, conspicuous vacuole usually beside the contractile vesicle; anterior extremity terminating in a rounded, beak-like projection directed toward the left-hand border; the right-hand margin usually evenly convex and continued through a sinistrally directed concavity into the tail-like prolongation, the whole border thus presenting an elongated S-shaped outline; the left-hand margin somewhat sigmoid and continued into the tail as a sinistrally directed convexity; the posterior tail-like prolongation retractile to a short, conical projection, but when extended, curved toward the right-hand border and forming about one-third of the entire length of the body; cuticular cilia long and fine; peristome field a long channel occupying somewhat less than the anterior two-thirds of the left-hand border, taking its origin at a short distance posteriorly to the beak-like apex, the margin bearing the adoral cilia projecting laterally, its outline sigmoid, its free edge conspicuously thickened; adoral cilia long, continued around the mouth and into the narrow, ciliated, anteriorly curved pharynx; the undulating membrane large, delicate and very flexible, its base of attachment extending obliquely within the adoral channel and about the posterior margin of the oral aperture; nucleus conspicuous, moniliform, more or less sigmoid, obliquely and subcentrally placed; contractile vesicle single, spherical, posteriorly located near the left-hand border at the base of the tail-like prolongation. Length of body $\frac{1}{300}$ inch. Habitat—Standing water, among the residual detritus at the bottom.

This noble infusorian is represented in figure 2, magnified about 380 diameters. Its habitat seems to be restricted to that just mentioned, as I have been unable, even after careful search, to take it elsewhere, and from thence only after the sediment has been disturbed and the animalcule captured before it could again bury itself. It is essentially a mud-loving form, and seems rare. I have taken but six individuals after prolonged searching. The nucleus is commonly composed of from four to seven nodules, including the single one usually laterally attached.

The numerous scattered vacuoles are generally circular in optical outline; they frequently collect together near the median line and gradually disappear. The larger, more conspicuous one near the pulsating vesicle is commonly of irregular outline and quite persistent, seldom more than slightly changing its form.

Apgaria ovata, sp. nov. (fig. 3).—Body irregularly ovate, length once and one-half to twice the breadth, the posterior region somewhat inflated, the anterior flattened, the beak-like apex short, acute and inconspicuous or obsolete; the posterior extremity usually rounded and the short, acute, conical tail-like prolongation entirely retracted; peristome field occupying the anterior three-fourths of the left-hand border, its margins sigmoid, not projecting laterally; the adoral ciliary fringe originating at the anterior apex; undulating membrane narrow, attached to the basal third of the right-hand peristome border, not obliquely inserted and not entirely surrounding the mouth posteriorly; nucleus ovate, situated in the anterior body-half near the left-hand border; contractile vesicles two, posteriorly placed, pulsating alternately; anal aperture large, in close proximity to the contractile vacuoles. Length of body $\frac{1}{300}$

inch. Habitat—The surface of submerged twigs and decaying leaves at the bottom of shallow pools.

The tail of this form is the shortest of any yet observed, and an individual in any other than the retracted state represented in figure 3 is uncommon, although the infusoria are not rare. It is also the least changeable in form, a slight elongation of the body being about the extent of its alteration. When in motion, like the others it rotates on its longitudinal axis, but it is not rapid. The animalcule frequently remains motionless in the field of the objective for half an hour at a time, either feeding or awaiting the result of its ciliary currents. Its appetite is voracious. Spores, unicellular algæ, small infusoria, diatoms, almost any minute living thing seeming acceptable. The undulating membrane is active in the feeding process, waving and bending across the oral fossa and forming the roof of a food-trap which, if occasion demands, descends and thrusts the morsel into the mouth. The anal aperture is remarkably large and, at times, is temporarily conspicuous as a postero-terminal depression with a puckered margin. It frequently opens in connection with the pulsating vacuoles, a great part of the creature's posterior extremity then appearing to give way, beaded threads of sarcode sometimes streaming into the water, and rapidly receding. The pulsating vacuoles after contraction are followed by several internal well-marked sarcode threads or folds, which gradually fade away to reappear after the next pulsation. Their function I have not even conjectured; neither have I observed them in any other infusorian. There is one condition, however, in which the tail is well exhibited, and that is during the reproductive process. This takes place by longitudinal fission, one individual becoming three by the almost simultaneous separation of two zooids from the body of the parent, as in figure 4. After the process the tail-like projections are withdrawn and the young differ from the mature forms in size only. I am not aware that a similar triple longitudinal fission has been previously observed.

Apgaria elongata, sp. nov.—Body elongate-ovate, flattened, three to four times as long as broad; beak-like apex distinct; posterior portion continued as a centrally directed, acute, conical tail-like prolongation, which, when extended is about one-fifth the entire length of the body; peristome field occupying the anterior one-half of the left-hand border, its margins scarcely sigmoid and not projecting laterally; the adoral ciliary fringe originating at a short distance posteriorly to the beak; undulating membrane wide, attached to the basal one-half of the right-hand margin of the peristome channel, its insertion not conspicuously oblique and not surrounding the mouth; pharynx short, ciliated; nucleus elongate-ovate, in the anterior dy-half near the left-hand border; contractile vesicles two, tuated at the base of the tail-like projection, and contracting ternately. Length of body $\frac{1}{300}$ to $\frac{1}{350}$ inch. Habitat—The rface of water-soaked twigs and decaying leaves at the ttom of shallow pools.

Figure 5 represents this infusorian with the tail partially ithdrawn, as most commonly seen; figure 6 an outline of the me part extended. Its movements are the most rapid, and s changes of form the greatest of any member of the genus et met with. The body is very flexible, and is frequently wisted temporarily.

The systematic position of the genus is probably near that f Blepharisma.

Another animalcule collected in some abundance in one of he first gatherings of early spring seems to have no recog izable generic resting-place. It may be characterized as ollows:

Ileonema, gen. nov. (Greek *eileo*, to twist; *nema*, a thread.)—Body flask-shaped, depressed, elastic, entirely ciliate; flagellum single, inserted at the narrow anterior extremity, flexible but not vibratile, the basal half large, thick and apparently twisted, the distal half fine, thread-like; oral aperture terminal, perforating the apex of the neck-like portion; pharynx distinct; nucleus sub-spherical or broadly ovoid, sub-central; contractile vesicle single, posterior placed; anal aperture postero-terminal.

Ileonema dispar, sp. nov. (fig. 7.)—Body transparent, granular, flexible, flask-shaped, longitudinally striate, the length about three times the breadth, contracting to a short ovoid form or extending until clavate; the ventral surface flattened, the dorsal convex and bearing a single longitudinally disposed row of short hair-like perpendicular setæ; cilia long and fine, thinly clothing the surface; entire flagellum one-half the length of the body, the basal half thick, obliquely grooved and presenting a twisted or cord-like appearance, slightly tapering yet suddenly constricted at the beginning of the finely filamentous distal one-half; oral aperture at the base of the flagellum; pharynx elongate-fusiform, longitudinally plicate, apparently composed of delicate elastic, rod-like elements; nucleus ovoid, sub-central; contractile vesicles two, postero-terminal, close to the anal aperture. Length of body $\frac{1}{200}$ inch. Habitat—Among algæ and decaying leaves at the bottom of shallow pools.

This bottle-shaped infusorian (fig. 7) was taken from among those delicate algæ which grow so abundantly in all quiet waters, and seem to cling like soft green clouds to leaves of grass and fragments of sticks and twigs in the shallow wayside ools of early spring. Its movements are evenly swimming without rotation and without much hurry. Its changes of form are, however, quite constant as it rests among the algal threads and lengthens the entire body into a club-shaped creature searching for food, or contracts into an egg-shape with a short, narrow neck. Normally its contour closely resembles that of *Tracheophyllum apiculatum* (Perty), C. & L. If, from the latter, the acutely conical anterior apex be removed, and the flagellum of *Ileonema* be added, the result woùld be a species of the genus now under notice, the likeness between the contracted forms being also striking.

The fine long cilia are not abundant. They vibrate irregularly and, to a certain extent, independently of each other.

The distal one-half of the flagellum is extremely fine, and is often absent, as, indeed is the entire appendage of individuals kept long in confinement. When the filamentous portion has been lost, the cord like half frequently ends in a bulbous enlargement, and even this the animalcule often loses, apparently without injurious results. This bulb seems to be sticky; it at least easily attaches itself to foreign bodies, and I have witnessed its owner, after several attempts, forcibly tear itself loose and lose the bulb. The whole flagellum is generally carried trailing and curved to one side, occasionally being extended and used apparently as a feeler.

If this organism is a member of Claparède and Lachmann's Cilio-Flagellata, then the diagnosis of that order must be somewhat modified. As it now stands the description states tha the flagellum is the chief organ of locomotion. With *Ileonem dispar* that appendage has no active connection with the animalcule's movements. Its position in the latest scheme of classification seems to be so close to the indistinctly defined line o separation between the Flagellata-Eustomata and the Cilio Flagellata, that it may be considered a link intimately connecting the two orders. Only a slight exercise of the observer' imagination is needed to put into vibration the filiform dist portion of the non-flexible, non-vibratile-flagellum, and to mor densely clothe the cuticular surface with shorter, more un formly moving cilia, in order to produce a typical member the Cilio-Flagellata. When the flagellum has been lost, th infusorian possesses no character to distinguish it from th Holotricha, and if first met with in this condition any observ would classify it in that order. As it is, it makes the line o demarcation between these orders still more obscure.

I was at first disposed to consider the pharynx a membrano tube whose walls are thrown into longitudinal folds, but suc interpretation was precluded by further observation. The passage is very dilatable, and the infusorian has the habit of widely expanding the posterior or internal extremity, as the body assumes the ovate form, when folds would become extinct and rods or fibrillæ more conspicuous, which is in fact the case. That an elastic membrane connects the rod-like constituents of the passage, I have not been able to determine. My impression, however, is that none exists, the pharynx being merely an elongated cage-like structure open at each end, its delicate bars attached only around the oral aperture.

The following minute creatures are also apparently undescribed. They are deliberate, but eccentric in their movements, with the additional eccentricity of appearing to float back downward, having in that position the convex surface which an observer would at first glance decide to be the dorsal. That it is in reality the ventral aspect is proven, it would seem, by the fact that the short, trailing flagellum not only takes its origin from a point on that surface, but is habitually held beneath the convexity. It is scarcely possible that a non-vibratile flagellum could be of much service as a drag or as a pivot on which to turn, as this infusorian turns, if carried above the dorsum. Yet the animal frequently moves with this convex part directed upward, although this is the less common position. The long flagellum is entirely flexible, but usually only the distal extremity is vibratile. It is commonly held directed stiffly and obliquely toward one side as the animalcule floats with either surface downward, as shown in the figures. In fig. 8, is delineated the ventral aspect to exhibit the comparative length, origin, and usual position of the short flagellum.

If both the superior and inferior surfaces were equally convex, the creature would scarcely have formed so interesting a study, but the former, or dorsal aspect bears a subcentral, longitudinal channel or depression extending from the apex to the posterior extremity, thus giving the infusorian, when seen "end on," or in transverse optical section, a concavo-convex outline, somewhat like that of a longitudinal slice of a bean. This grooved surface is represented in fig. 9.

When moving through the water, it advances in a direct course steadily and not rapidly for a few moments, when it quickly and abruptly turns aside at an acute angle, the long flagellum then being thrown into indescribable curves and flexures, but in the general direction of the route to be taken.

No distinct oral aperture is visible. On several occasions numerous minute green particles, presumably of food, have been noticed within the endoplasm.

In its generic position it approaches nearest to Stein's *Colponema*, but is refused admission to that genus by the absence of the anterior curvature, by the apical origin of the trailing flagellum, and by the presence of a dorsal instead of a ventral groove. If the channel-bearing surface should be assumed to be the ventral, Stein's genus would still be unable to receive the infusorian, since the short flagellum would then take its origin from the dorsal aspect, whereas in *Colponema*, one of these lash-like appendages arises from near the center of the ventral groove. Consequently, although a minute atom of vitality, it seems to demand recognition as the type of a new genus, of which the following may be taken as the diagnosis.

Solenotus (Greek *solen*, a channel; *notos*, the back), gen. nov.—Infusoria free-swimming, not changeable in shape, ovate, the anterior extremity slightly pointed but not curved to either side, the ventral surface convex, the dorsal concave, with a subcentral, longitudinal groove or channel; flagella two, diverse in length, one vibratile, the other trailing, both taking their origin anteriorly, the shorter from the smoothly convex aspect, not from the groove; anal aperture postero-terminal.

S. apocamptus (Greek *apokampto*, to turn aside), sp. nov.—Body depressed ovate, the length about one and one-third times the width; the anterior body half somewhat flattened, the anterior extremity with rounded borders but tapering to an acute, slightly projecting apex; the posterior body half narrowing, the extremity convex but somewhat truncate; ventral aspect smoothly convex; dorsal groove narrowest at its anterior origin, widening and thence continuing evenly to its posterior termination; flagella diverse in length and thickness, the longer and larger, once to one-half times as long as the body, inserted at the apex, and commonly held stiffly and obliquely in advance, the distal end alone vibrating; the shorter trailing, about one-third the length of the body, slender, arising from a point at a little distance from the anterior apex of the convex or dorsal surface; endoplasm granular especially posteriorly; contractile vesicle single, small, located anteriorly near the right-hand border; nucleus obscure, apparently placed subcentrally near the left-hand margin. Length of the body $\frac{1}{2500}$ to $\frac{1}{3750}$ inch. Habitat—Standing water with Myriophyllum.

Solenotus orbicularis, sp. nov.—Body suborbicular, the anterior apex obtuse, the posterior extremity rounded not truncate, the posterior one-half of the left-hand border angular; dorsal groove broad and shallow; ventral surface evenly convex; flagella, nucleus and contractile vesicle similar to those of the preceding species. Length of the body $\frac{1}{2200}$ with $\frac{1}{2500}$ inch. Habitat—Near the bottom of the shallow water of small pools.

This infusorian (fig. 10) differs from that described as *Solenotus apocamptus*, chiefly in its contour, its shorter dorso-ventral or vertical diameter, and in the shallowness and greater omparative width of the dorsal depression. Its movements re similar to those of *S. apocamptus*, the long flagellum being eld somewhat more obliquely than with that species. The ody is frequently elevated during its progression so that the pex seems to be held in contact with the slide, a position not bserved with *S. apocamptus*. The anterior body half is transarent; colorless corpuscles and green food-particles collected osteriorly render that part semi-opaque.

Trenton, N. J.

ART. VIII.—*The Causes of Variation*; by ROMYN HITCHCOCK.

THE recent studies of Dr. W. B. Carpenter upon *Orbitolites*, which were noticed in the April number of this Journal, are of special interest owing to the remarkable manner in which the stages of variation and development have been traced. The monograph by Dr. Carpenter, published in the Reports of the 'Challenger' Expedition, was the subject of some remarks recently made by the writer before the Biological Society of Washington, in which an effort was made to explain how such a simple sarcode organism as the animal *Orbitolites* had been led to produce a shell of complex form. Dr. Carpenter regards it as the expression of a not understood "progressive tendency along a definite line towards a higher specialized type of structure in the calcareous fabric." This, however, is merely a statement of the facts observed, and in nowise assists in their explanation. Elsewhere it may be gathered from the author's words that he regards the complex shell as significant of a "*plan* so definite and obvious, as to exclude the notion of '*casual*' or '*aimless*' variation."

The facts seem capable of a somewhat different interpretation, which seems more in accord with our present knowledge of simple organisms, and quite sustaining the views of Darwin that "plan," in the sense used by Dr. Carpenter, should be, superfluous. For if there be an inherent tendency to variation among these organisms, as Dr. Carpenter seems to believe, how do we explain the persistence of the original orbitoline type *O. tenuissima ?* Biologists seek to discover the causes of variations which they observe, but it seems not less important that the persistence of types should also be explained. *O. tenuissima* is a very ancient species, and surely any inherent tendency to change would have manifested itself during the long period of its existence, even under unfavorable conditions.

The observations I have to offer may be said to relate entirely to change of environment, but their tendency is to demonstrate that the changes observed in the shells of this family are not due to any inherent tendency resulting in a definite plan, but that they are due to causes easily understood.

It is far from my intention to deny a definite plan of growth to these organisms. But plan of growth does not imply that there have been causes acting within the organism—special tendencies of the protoplasm toward higher structure. It seems to be such an assumption that has led Dr. Carpenter to speak of a "not understood" progressive tendency, etc. In my opinion the causes of such progression as can be observed are easily understood; and the plan of growth becomes a natural consequence of these causes, which are purely physiological, and independent of any supposed tendency to variation. While Dr. Carpenter, on the one hand, seems to regard variation as due to an inherent tendency of the protoplasmic body, the writer, on the other hand, attributes it entirely to the more or less favorable conditions of life of the different species. Moreover, I am quite unable to understand how any inherent tendency to variation impressed upon the sarcode could fail to find expression in some differentiation of the sarcode, which in the cases in question has not been observed.

The same view seems to be held by O. Schmidt who, in his "Grundzüge einer Spongien-Fauna des Atlantischen Gebietes," alludes to Dr. Carpenter's previous studies, and compares the changes observed in the sponges and foraminifera. He says the changes in the latter are found in the general habit of the form and the variable grouping of the chamber-systems, while among the sponges the variation is in the microscopic detail. "One may speak of the microscopic form of foraminifera but not of microscopic elements."

The complexity of the shell is merely in the multiplicity of chambers and the manner of their intercommunication. The process of growth, even in the complex *O. complanata*, is in all respects identical with that in other species, and in no essential feature differs from that of *Peneroplis*. What Dr. Carpenter designates as a "higher specialized type of structure" does not represent an advanced degree of specialization in any part; nor can we discover any advantage to the organism arising therefrom. It is true there is an advance in complexity, but unless accompanying this there is an evolution in function, or unless it results from some effort of adaptation which confers some benefit upon the organism, it seems not proper to regard complexity of shell-structure as a proof of biological advancement.

Seeking for an explanation of the cause of the increased complexity of shell-structure, so beautifully illustrated in the milioline family, the writer was led to the conclusion that it is entirely due to the favorable conditions of life and the abundance of food available. It is true, as already said, this may be regarded as a mere statement of the influence of environment causing variation, but a careful consideration of the subject will show that there is a broad distinction between environment as a cause of variation, and adaptation to environment; for in this case we are unable to perceive any benefit to the organisms arising from their adaptation to changed conditions.

If it be said we can seldom discover the benefits supposed to be derived from adaptation, it may be answered that it is usually possible to infer how the changes observed may prove beneficial. In the case under consideration, however, an examination of the changes that have taken place does not indicate any possible benefit to the organism. The multiplication of chamberlets necessitates very intimate intercommunication for the transference of food and the continuation of the processes of life. The organism is not thereby better adapted to its surroundings, but is made more dependent for its existence upon the continuance of the favorable conditions under which it has developed. The advance in complexity—the multiplication of chamberlets—would only be possible under the most favorable conditions, for all the nutriment received by the interior segments must be collected by the sarcode at the margin of the shell, and the necessary food could only be obtained where the supply was abundant. It may be conceived that if *O. complanata* were placed in situations less favorable as regards food it would die of starvation owing to the quantity of inner sarcode requiring nourishment, while *O. tenuissima* needs only more favorable conditions as regards food, and perhaps temperature, to become as highly complex in structure as the last-mentioned species. As a further proof of the influence of environment leading to changes which cannot be regarded as special adaptations, in the usual meaning of the word, the forms of *O. complanata* found on Fiji reef are especially characterized by thick, plicated margins, as though growth proceeded with too great rapidity to produce symmetrical disks, and these forms are associated with the largest representatives of the species.

The distinction above referred to seems an important one, which, if it has already been recognized, has not been prominently brought forward in the writings with which I am familiar. Before the Biological Society the subject was briefly considered in the following words:

"Regarding the subject from this point of view we are led to examine more closely the relations between the spiral and the cyclical methods of growth. Their intimate relation is only noticeable when we observe how one has been derived from the other. When the spiral growth of *Orbiculina* produces a complete circular disk, further spiral growth becomes impossible, and if we concede that the extrusion of the sarcode to form successive chamberlets is due to nutrition and growth, the cyclical plan then becomes a necessity. In this way it may be supposed cyclical growth originated, purely a result of nutrition—not by adaptation to environment, but as a result of it; not because such growth is or ever was better adapted to the conditions of life.

"We find here a steady course of variation a result of physiological processes, independent of those external causes to which we are accustomed to attribute such changes. These variations, as successively produced, have been perpetuated through inheritance, until the plan of growth has, in some species, totally changed. Herein, therefore, we may find an indication of how the plan of growth originated, and a suggestion that the inscrutable laws which govern the progress of evolution may each have beginnings equally simple, and not beyond the range of human insight to discover. Evolution in this case seems not to be a result of a definite plan of growth, but the plan of growth is the result of physiological processes. However great and important the influences of environment and selection may have been in the production of genera and species, perhaps the attractiveness of the idea, and the ease with which it enables us to dimly understand many biogenetic problems, permits us to lose sight of other influences more obscure but of equal importance in the history of life."

This view of the subject seems to derive still further suppor from the geographical and bathymetrical distribution of th species. Without entering into a lengthy discussion of th part of the subject, it may be said that as a rule the more con plex species are found in the warmer waters, under conditio most favorable to the activity of nutritive processes. As example, the very large specimens of *O. complanata* from F reef may be taken. On the other hand, the ancestral form *tenuissima* still inhabits the colder and deeper waters, retaini the simple characters of its earliest known condition.

National Museum.

ART. IX.—*Crustacea of the Albatross Dredgings in* 1883; by SIDNEY I. SMITH.

VERY little has yet been published in regard to the zoological results of the deep sea explorations carried on during the summer of 1883, by the United States Fish Commission, although the dredgings were among the most important yet made. Some of the remarkable forms of fishes discovered have been described by Drs. Gill and Ryder, but the writer's report on the decapod crustacea (80 pages of text with 10 plates), recently put in type for the Fish Commission Report for 1882, is the first detailed report on the zoological collection made by the Albatross, and affords an opportunity for a brief review of the results of the study of the higher crustacea, which is here published by permission of the Commissioner of Fish and Fisheries.

The dredgings of the Albatross extended from off Cape Hatteras to the region of George's Banks. The number of dredging stations was 116, of which 30 were in less than 100 fathoms, 35 between 100 and 500 fathoms, 19 between 500 and 1000 fathoms, 27 between 1000 and 2000 fathoms, and 5 below 2000 fathoms. The whole number of species of Decapoda determined from these stations is 72, but of these at least 15 are true shallow-water species. Of the remaining 57 species, 40 were taken below 500 fathoms, 29 below 1000 fathoms, 13 below 2000 fathoms, and 6 at a single haul in 2949 fathoms. Of the 29 species taken below 1000 fathoms, 21 are Caridea or true shrimp, and the 8 higher species distributed as follows: 2 Eryontidæ, 3 Galatheidæ, 1 Paguroid, 1 Lithodes, and 1 Brachyuran belonging to the Dorippidæ. It is interesting to compare these results with the lists of the fauna of the North Atlantic below 1000 fathoms, given by the Rev. Dr. Norman in the presidential address to the Tyneside Naturalists' Field Club, published last year. In Dr. Norman's lists only 12 species of Decapoda are recorded, none of them from as great a depth as 2000 fathoms, and of these 12 species, 7 were known only from the Blake dredgings of 1880.

The following are some of the more interesting new forms: a new genus of Brachyura allied to *Ethusa*, 1496 to 1735 fathoms; an Anomuran belonging to A. Milne-Edwards' new genus *Galacantha*, 1479 fathoms; two species of *Pentacheles* (a genus of Eryontidæ allied to *Willemœsia*), between 843 and 1917 fathoms; a stout Palæmonid (*Notostomus*), six inches long and intense dark crimson in color, 1309 to 1555 fathoms; a gigantic *Pasiphaë*, eight and one-half inches long, 1342 fathoms; three species of a remarkable new genus allied to *Pasiphaë*, and also to *Hymenodora* and some other genera of Palæmonidæ, which shows that *Pasiphaë* is closely allied to the Palæmonidæ; a large Penæid, a foot in length, referred to the little known genus *Aristeus*; and a large *Sergestes* three inches in length.

The great size of some of these new species of shrimp is remarkable, but is far exceeded by two of the previously described crabs. *Geryon quinquedens*, from 105 to 588 fathoms, is one of the largest Brachyurans known, the carapax in some specimens being five inches long and six broad, while one specimen of the great spiny *Lithodes Agassizii* measures seven inches in length and six in breadth of carapax, and the outstretched legs over three feet in extent.

Among the Schizopoda there are two large species of *Gnathophausia*, one over four inches in length, and a *Lophogaster*, all from below 2000 fathoms. One of the most interesting Schizopods is a small [illegible] genus of Euphausidæ) from 398 to 1537 fathoms, of which one female was found carrying eggs. The eggs are carried [illegible] flattened mass beneath [illegible] together by some glu[illegible] to the third pair [illegible] appendages). [illegible] regard to the egg[illegible] as far as I know, [illegible] any of the [illegible]

[illegible] very few in [illegible] among [illegible] ry remarkable case is that of *Parapagurus pilosimanus*, was taken at fifteen stations and in 250 to 640 fathoms e Fish Hawk and Blake in 1880–'81–'82, and in great lance at one station, in 319 fathoms, where nearly four 'ed large specimens were taken at once. All these earlier nens were inhabiting carcinœcia of *Epizoanthus paguri-* . In the dredgings last summer the *Parapagurus* was at seven stations ranging in depth from 1731 to 2221 ns, but none of the specimens were associated with the species of *Epizoanthus*, some being in a very different s of *Epizoanthus*, others in naked gastropod shells, and thers in an actinian polyp.

triking characteristic of the deep-sea crustacea is their red dish color. A few species are apparently nearly colorless, e great majority are some shade of red or orange, and I seen no evidence of any other bright color. A few species between 100 and 300 fathoms are conspicuously marked carlet or vermilion, but such bright markings were not d in any species from below 1000 fathoms. Below this , orange red of varying intensity is apparently the most on color, although in several species, very notably in the *omus* already referred to, the color was an exceedingly e dark crimson.

eyes of these abyssal species are even more remarkable their colors, as the following list of the Decapoda and Schizopoda taken below 2000 fathoms by the Albatross, he notes which follow, will show:

1.	Parapagurus pilosimanus	1731 to 2221 fathoms.
2.	Pontophilus abyssi	1917 to 2221
3.	Nematocarcinus ensiferus	588 to 2030
4.	Acanthephyra Agassizii	105 to 2949
5.	Acanthephyra, sp.	2929
6.	Gen. allied to Acanthephyra	1395 to 2929
7.	Hymenodora glacialis	888 to 2030
3.	Parapasiphaë sulcatifrons	516 to 2929
9.	Parapasiphaë compta	2369
0.	Amalopenæus elegans	640 to 2369
1.	Aristeus? tridens	843 to 2221
2.	Hepomadus tener	2949
3.	Sergestes mollis	373 to 2949
4.	Gnathophausa, sp.	858 to 2033
5.	Gnathophausa, sp.	959 to 2949
6.	Lophogaster, sp.	1022 to 2949

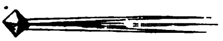
every one of these sixteen species the eyes are present, in rmal position, and distinctly faceted. In Nos. 3, 4, 5, 6, d 12 the eyes are well developed, black, and while some- smaller than in the average Palæmonidæ and Penæidæ, are not conspicuously smaller than in many allied shallow-water forms. In 1 the eyes are black but conspicuously smaller than in the allied shallow-water species. In 13 the eyes are black and of moderate size. In 9 they are apparently black or nearly black and small. In 2 they are nearly colorless in alcoholic specimens and rather larger than usual in the genus, but considerably smaller than in *Pontophilus gracilis*, a very closely allied species found in 200 to 500 fathoms. In 7 and 8 they are small and light colored. In 10 they are rather small and dark brown. In 14, 15 and 16 they are not conspicuously different in size from those of allied shallow-water species and are dark brown.

However strong may be the arguments of the physicists against the possibility of light penetrating the depths from which these animals come, the color and the structure of their eyes, as compared with blind cave-dwelling species, show conclusively that the darkness beneath two-thousand fathoms of sea-water is very different from that of ordinary caverns. While it may be possible that this modification of the darkness of the ocean abysses is due to phosphorescence of the animals themselves, it does not seem probable that it is wholly due to this cause.

The large size of the eggs is a marked feature in many of the deep-water Decapoda. The eggs of *Eupagurus politus* from 50 to 500 fathoms, are more than eight times the volume of those of the closely allied and larger *E. bernhardus* from shallow water, and in *Sabinea princeps*, from 400 to 900 fathoms, they are more than fifteen times as large as in *S. septemcarinata* from 25 to 150 fathoms. The most remarkable cases are among the deep-water genera. *Galacantha rostrata* and *G. Bairdii*, from between 1000 and 1500 fathoms, have eggs 3^{mm} in diameter in alcoholic specimens, while in the vastly larger lobster they are less than 2^{mm}. The largest crustacean eggs known to me are those of *Parapasiphaë sulcatifrons*, a slender shrimp less than three inches long, taken between 1000 and 3000 fathoms. Alcoholic specimens of these eggs are fully 4 by 5^{mm} in shorter and longer diameter, fully ten times the volume of the eggs of *Pasiphaë tarda* from 100 to 200 fathoms, more than three hundred and fifty times the volume of those of a much larger shallow-water *Palæmon*, and each one more than a hundredth of the volume of the largest individual of the species. From the peculiar environment of deep-water species it seems probable that many of them pass through an abbreviated metamorphosis within the egg, like many fresh-water and terrestrial species, and these large eggs are apparently adapted to producing young of large size, in an advanced stage of development, and specially fitted to live under conditions similar to those environing the adults.

ART. X.—*Crystallized Gold in prismatic forms;* by WM. P. BLAKE.

IEAR Clancey, on Clancey Creek, Jefferson County, Mon- a, minute crystals of gold occur which present the novelty a solid octahedral nucleus, or head, with a long divergent sh-like or prismatic development of the gold on one side, or le, giving the whole the appearance of the drawings usu- made to represent comets, and as represented in the accom- ıying figure. The total length of these crystals does not eed from two to three millimeters (about one eighth of inch), and the minuteness of the cross-section of the delicate ergent prisms makes it extremely difficult to determine ir form. They are, also, very brittle, and they appear to ave or break asunder in planes at right angles to their length. ıder the microscope these prisms are n to have three or more planes and ey appear to be hexagonal. They taper gradually and uni- rmly to a sharp point, and are sometimes composite, being part of their length formed of two or more prisms joined le to side.



Among the fragments, one larger and broader than the hers exhibits a solid octahedral nucleus with a flat or plate- e projection on opposite sides. This projection shows dis- ıctly on one side a line of composition through the center, ith divergent lines or markings at an angle of 45° with the edial line, corresponding in angle and in direction with small anes on the edges. The same side of this plate which shows e medial line of composition is slightly trough-shaped, being rmed of two plane surfaces inclined towards the medial line. ne opposite side is rough, with angular projections.

These plate-like projections from the octahedron are much rger than the prisms, but it is probable that the origin and ystallization of both are similar. The plates have the appear- ce of being formed by the combination or twinning of octa- drons parallel with their faces with their main axes inclined wards each other at an angle of 60°.

HEXAGONAL PRISMS OF GOLD.

At Sonora in Tuolumne County, California, I obtained some ars ago from the late Dr. Snell a sample of very small but illiant prisms of gold. Under the microscope these are seen be hexagonal prisms with smooth and brilliant planes and rminated at one or both ends with a pyramid. They appear to be well formed crystals without marks of composition or twinning. The basal plane is also visible. The angle between the prism (*I*) and the pyramid (1) is approximately 130°, by measurement kindly made for me by Prof. E. S. Dana. They resemble the prismatic gold crystals figured by Prof. A. H. Chester,* and obtained artificially by digesting gold amalgam in nitric acid. He obtained 136° for the angle $O \wedge 1$, which would give 134° for $I \wedge 1$. It is possible that the Sonora crystals are also artificial, but there is no means of verifying their origin. Similar crystals obtained at Angels Camp in the same region were said to have been taken from a cavity in quartz.

The crystals described by Prof. Chester contained 6 per cent of mercury. Le Sage, a writer of the last century, 1777, also mentions prismatic crystals of gold obtained by heating the amalgam. He describes them as square prisms with terminal pyramids of four planes, and considered them to be lengthened octahedrons.

Mill Rock, New Haven, June, 1884.

ART. XI.—*Mode of action of Shell- and Rock-boring Mollusks;* by Professor F. H. STORER. (Letter addressed to J. D. Dana.)

As a teacher of Agricultural Chemistry, I have frequent occasion to insist upon the readiness with which saline compounds are decomposed by way of osmose, when put in contact with moistened membranes, and particularly when in contact with living membranes, such as cover the rootlets of plants. It has often occurred to me that a similar power of osmotic dissociation, inherent in certain animal tissues, affords the true explanation of the mode of action of many rock- and shell-boring mollusks. The power of plant-roots to decompose chemical compounds, such as common salt, for example, is only too well known to investigators. It has been in fact a serious practical hindrance to the use of the method of research known as water-culture, which has played a highly important part in the study of the question what chemical substances are necessary for feeding plants. Knop† found, for example, on growing maize plants in solutions containing the nitrates of lime and potash that the nitrogen of these compounds was taken in more rapidly by the plant than were their basic constituents, so that the solution outside the roots became alkaline through accumulation of the bicarbonates of potash and of lime. So, too, when Rautenberg and Kühn tried to sup-

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* This Journal, July, 1878, III, vol. xvi, 32.

† See his "Lehrbuch der Agricultur-Chemie," i, 603.

aize plants with nitrogen by feeding them with ammo-
chloride, they found that this salt was decomposed and
chlorhydric acid, for which the plant had no need, accu-
ted to such an extent outside the roots that it proved fatal
e life of the plants.* The well-known power of rootlets
ive their imprint on bones and bits of marble, with which
happen to come in contact in the earth, may perhaps be
to the corrosive action of acids set free in this way by
tic action of the roots on matters in the soil-water;
gh it is perhaps equally probable that the lines are etched
irbonic acid which is known to be given off by plant
.

view of these familiar facts, there seems to be good reason
elieving that the boring of calcareous shells and rocks by
ous mollusks depends on the formation of chlorhydric acid
igh decomposition of sea salt by certain tissues of the bor-
nimals; these tissues being kept meanwhile in direct con-
with the shell or the rock to be bored. It is to be sup-
d, of course, as is the case indeed with plants, that the
mposition of the sea salt, or, in other words, the secretion
e chlorhydric acid, occurs in particular organs specially
d to the purpose; but it is to be noted that in sea water
organs find an unlimited supply of the acid-yielding
rial. In so far as I can gather from a cursory view of an
miliar literature, it appears to be a fact that the boring
tures are found chiefly if not always in salt or brackish
r.

hanks to an occasional moment of attention to the ichthyo-
al and conchological studies of my father, I have been
liar from childhood with the curiously corroded bivalves
h are occasionally found in the stomachs of certain fishes
n on our New England coast, notably, unless my memory
ives me grossly, in the stomach of the so-called ling or eel-
ed blenny (*Zoarces anguillaris*) some of which specimens it
ld be said are extremely well-fitted to give a student just
eptions as to the great chemical activity of gastric juice.
e twenty-five years ago, in a discussion at a meeting of the
on Society of Natural History relating to the boring of
stones by echinoderms, I cited this evidence of chemical
n in the stomach of a cold-blooded fish as militating
nst the opinion that the echinoderm excavations "might be
ted by their vibratory ciliæ"; and, in opposition to asser-
s that the hypothesis of chemical action was inadmissible,
e a chemical agent powerful enough to soften rocks could
dly fail to destroy the tissues of the animal that produced
I maintained that much of what we know as to the diges-

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*See Johnson's "How Crops Grow," New York, 1868, pp. 170, 171.

tion of food by animals should count in favor of the chemical view of rock boring. I remember to have said, on that occasion, that it might as well be argued that tripe could not be digested in the stomach of a dog without corroding the walls of his stomach as to say that a marine animal could not bore rocks by chemical means without destroying himself.

During the last six or eight years I have had frequent opportunity to observe the common whelk (*Buccinum*) in the act of boring through the shells of mussels and barnacles, and I have interrupted his operations, scores of times, at all conceivable stages of progress. As is well known, the whelk, having seated himself upon a mussel, or other shell, thrusts out a proboscis whose end is kept continually in contact with one particular point on the mussel shell, in such wise that a small round hole is there speedily perforated through the calcareous matter. The moment the hole is completed the whelk protrudes his proboscis still farther, thrusting it into the actual flesh of the mussel, and gradually sucks out and consumes the whole of this flesh ; he then passes to another mussel, drills another hole in its shell and eats the fleshy contents of the shell, as before It has been not a little debated whether the process of perforation in this case is an act of corrosion by acid or of chipping or filing by teeth. Osler (Phil. Mag., 1832, p. 507) maintained long ago that " the perforation is effected by a succession of strokes, following each other at intervals shorter than a second." He says, indeed, that he has distinctly heard these strokes by applying to his ear a patella that had a buccinum attached to it. He gives elaborate figures of the tooth-like, horney points on the tongue of buccinum, which he compares with a "center-bit;" and, in like manner, Agassiz and Gould* have figured the teeth of natica to show the analogy of the boring apparatus to a " file " or a " rasp." The powerful muscular development of the proboscis of buccinum would of itself lend some countenance to the idea that it drives a drill. But I must say that to myself the boring act, like the subsequent digestion of the invaded mussel, has always seemed to be a distinctly chemical process. That the denticles may aid somewhat in the boring, to remove mechanically bits of loosened or softened shell, and that they may afterwards serve to tear off or hook up meat from within the mussel seems probable enough, but I am strongly of opinion that an acid solvent is made to act upon the shell during the process of boring. It seems not improbable that the presence of free muriatic acid might be detected by appropriate chemical experiments made upon large tropical gasteropods. It might even be practicable, perhaps, to learn something in this sense, by studying some one of our own species

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* Principles of Zoology, p. 78.

ed in a sufficiently small aquarium. Possibly the oyster
Buccinum plicosum) might serve the purpose? or, better,
rge winkle (*Pyrula*)? or possibly even our common clam-
ring *Natica*?

XII.—*Memorials of* GEORGE ENGELMANN *and of* OSWALD HEER; by ASA GRAY.

he Report of the Council of the American Academy of Arts and Sciences, May, 1884.]

I. GEORGE ENGELMANN.

he death of Dr. Engelmann, which took place on the 4th
ruary last, the American Academy has lost one of its
few Associate Fellows in the Botanical Section, and
e one of its most eminent and venerable cultivators.
was born at Frankfort-on-the-Main, February 2, 1809, and
erefore just completed his seventy-fifth year. His father,
ıger member of the family of Engelmanns who for several
ıtions served as clergymen at Bacharach on the Rhine,
lso educated for the ministry, and was a graduate of the
rsity of Halle, but he devoted his life to education.
ing the daughter of George Oswald May, a somewhat
guished portrait-painter, they established at Frankfort,
ırried on for a time with much success, a school for young
, such as are common in the United States, but were then
elty in Germany.
rge Engelmann was the eldest of thirteen children born
marriage, nine of whom survived to manhood. Assisted
scholarship founded by "the Reformed Congregation of
fort," he went to the University of Heidelberg in the year
where he had as fellow students and companions Karl
per and Alexander Braun. With the latter he main-
an intimate friendship and correspondence, interrupted
y the death of Braun in 1877. The former, who mani-
unusual genius as a philosophical naturalist, after laying
undations of phyllotaxy, to be built upon by Braun and
, abandoned, through some singular infirmity of temper,
ening scientific career of the highest promise, upon which
ree young friends, Agassiz, Braun and Schimper, and in
rn Engelmann, had zealously entered.
barrassed by some troubles growing out of a political
ıstration by the students at Heidelberg, Engelmann in
ıtumn of 1828 went to Berlin University for two years;
ıence to Würzburg, where he took his degree of Doctor

in Medicine in the summer of 1831. His inaugural dissertation, *De Antholysi Prodromus*, which he published at Frankfort in 1832, testifies to his early predilection for botany, and to his truly scientific turn of mind. It is a morphological dissertation, founded chiefly on the study of monstrosities, illustrated by five plates filled with his own drawings. It was therefore quite in the line with the little treatise on the Metamorphosis of Plants, published forty years before by another and the most distinguished native of Frankfort, and it appeared so opportunely that it had the honor of Goethe's notice and approval. Goethe's correspondent, Madame von Willema, sent a copy to him only four weeks before his death. Goethe responded, making kind inquiries after young Engelmann, who, he said, had completely apprehended his ideas of vegetable morphology, and had shown such genius in their development that he offered to place in this young botanist's hands the store of unpublished notes and sketches which he had accumulated.*

The spring and summer of 1832 were passed at Paris in medical and scientific studies, with Braun and Agassiz as companions, leading, as he records "a glorious life in scientific union, in spite of the cholera." Meanwhile, Dr. Engelmann's uncles had resolved to make some land investments in the valley of the Mississippi, and he willingly became their agent. At least one of the family was already settled in Illinois, not far from St. Louis. Dr. Engelmann, sailing from Bremen for Baltimore in September, joined his relatives in the course of the winter, made many lonely and somewhat adventurous journeys on horseback in Southern Illinois, Missouri, and Arkansas, which yielded no other fruits than those of botanical exploration; and finally he established himself in the practice of medicine at St. Louis, late in the autumn of 1835. St. Louis was then rather a frontier trading post than a town, of barely eight or ten thousand inhabitants. He lived to see it become a metropolis of over four hundred thousand. He began in absolute poverty, the small means he had brought from Europe completely exhausted. In four years he had laid the foundations of success in his profession, and had earned the means for making a voyage to Germany, and, fulfilling a long-standing engagement for bringing to a frugal home the chosen companion of his life, Dora Hartsmann, his cousin, whom he married at Kreuznach on the 11th of June, 1840. On his way homeward, at New York, the writer of this memorial formed the personal acquaintance of Dr. Engelmann; and thus began the friendship and the scientific association which has continued unbroken for almost half a century.

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* The manuscript original of the *Antholysis*, in German, with the neat original drawings (the gift of the son), is now preserved in the Library of the Herbarium of Harvard University.

. Engelmann's position as a leading physician in St. Louis,
ll among the American as the German and French popu-
ı, was now soon established. He was even able in 1856,
ut risk, to leave his practice for two years, to devote most
e first summer to botanical investigation in Cambridge,
hen, with his wife and young son, to revisit their native
and to fill up a prolonged vacation in interesting travel
tudy. In the year 1868 the family visited Europe for a
the son remaining to pursue his medical studies in Berlin.
lastly, his companion of nearly forty years having been
ved by death in January, 1879, and his own robust health
g suffered serious and indeed alarming deterioration, he
l again for Germany in the summer of 1883. The voyage
o beneficial that he was able to take up some botanical
tigations, which, however, were soon interrupted by serious
toms. But the return voyage proved wonderfully restora-
and when, in early autumn, he rejoined his friends here,
could hope that the unfinished scientific labors, which he
ce resumed with alacrity of spirit, might still for a time be
d on with comfort. So indeed they were, in some meas-
after his return to his home, yet with increasing infirmity
no little suffering, until the sudden illness supervened
h, in a few days, brought his honorable and well-filled life
close.

the latter part of his life Dr. Engelmann was able to
ore considerable portions of his adopted country, the
ntains of North Carolina and Tennessee, the Lake Superior
n, and the Rocky Mountains and contiguous plains in Col-
o and adjacent territories, and so to study in place, and
the particularity which characterized his work, the *Cacti*,
Coniferæ, and other groups of plants which he had for
y years been specially investigating. “ In 1880 he made a
journey through the forests of the Pacific States, where he
for the first time in the state of nature plants which he had
ied and described more than thirty years before. Dr.
lmann's associates [so one of them declares] will never for-
his courage and industry, his enthusiasm and zeal, his
nding good nature, and his kindness and consideration of
y one with whom he came in contact.” His associates,
also all his published writings, may testify to his acuteness
servation, his indomitable perseverance in investigation, his
cal judgment, and a rare openness of mind which prompted
continually to revise old conclusions in the light of new
or ideas.

the consideration of Dr. Engelmann's botanical work,—to
ch these lines will naturally be devoted,—it should be
embered that his life was that of an eminent and trusted

physician, in large and general practice, who even in age and failing health was unable—however he would have chosen—to refuse professional services to those who claimed them; that he devoted only the residual hours, which most men use for rest or recreation, to scientific pursuits, mainly to botany, yet not exclusively. He was much occupied with meteorology. On establishing his home at St. Louis, he began a series of thermometrical and barometrical observations, which he continued regularly and systematically to the last, when at home always taking the observations himself,—the indoor ones even up to the last day but one of his life. Even in the last week he was seen sweeping a path through the snow in his garden to reach his maximum and minimum thermometers. His latest publication (issued since his death by the St. Louis Academy of Sciences) is a digest and full representation of the thermometrical part of these observations for forty-seven years. He apologizes for not waiting the completion of the half-century before summing up the results, and shows that these could not after three more years be appreciably different.

A list of Dr. Engelmann's botanical papers and notes, collected by his friend and associate, Professor Sargent, and published in Coulter's Botanical Gazette for May, 1884, contains about one hundred entries, and is certainly not quite complete. His [illegible] thesis already mentioned [illegible] is a treatise upon teratology in its [illegible] is a remarkable production for [illegible] student with botanical predi- [illegible] analysis of it in [illegible] Masters, the leading teratolo- [illegible] Moquin-Tandon's more [illegible] years afterwards. [illegible] from [illegible] was a [illegible] professed [illegible] as far as it [illegible] and [illegible] of [illegible]

[illegible] summarized [illegible] Dr. [illegible] were [illegible] knew [illegible] by [illegible] that [illegible] be [illegible] and of

oting himself to a particular genus or group of plants (gen-
ly the more difficult) until he had elucidated it as com-
ely as lay within his power. In this way all his work was
le to tell effectively.

'hus his first monograph of the genus *Cuscuta* (published in
Journal in 1842), of which when Engelmann took it up we
e supposed to have only one indigenous species, and that
peculiar to the United States, he immediately brought
to fourteen species without going west of the Mississippi
ey. In the year 1859, after an investigation of the
›le genus in the materials scattered through the principal
baria of Europe and this country, he published in the first
ıme of the St. Louis Academy of Sciences, a systematic
ıngement of all the *Cuscutæ*, characterizing seventy-seven
:ies, besides others classed as perhaps varieties.

fentioning here only monographical subjects, we should
.t refer to his investigations of the Cactus family, upon
ich his work was most extensive and important, as well as
ticularly difficult, and upon which Dr. Engelmann's author-
·is of the very highest. He essentially for the first time
ıblished the arrangement of these plants upon floral and
pological characters. This formidable work was begun in
sketch of the botany of Dr. A. Wislizenus's Expedition
m Missouri to North Mexico, in the latter's memoir of this
ır, published by the United States Senate. It was followed
by his account (in this Journal, 1852), of the Giant Cactus
the Gila (*Cereus giganteus*) and an allied species; by his
nopsis of the Cactaceæ of the United States, published in the
oceedings of the American Academy of Arts and Sciences,
56; and by his two illustrated memoirs upon the Southern
d Western species, one contributed to the fourth volume of
e series of Pacific Railroad Expedition Reports, the other to
nory's Report on the Mexican Boundary Survey. He had
ıde large preparations for a greatly needed revision of at least
e North American *Cactaceæ*. But although his collections
d sketches will be indispensable to the future monographer,
ry much knowledge of this difficult group of plants is lost by
s death.

Upon two other peculiarly American groups of plants, very
ficult of elucidation in herbarium specimens, *Yucca* and
ıave, Dr. Engelmann may be said to have brought his work
to the time. Nothing of importance is yet to be added to
ıat he modestly styles "Notes on the Genus *Yucca*," pub-
hed in the third volume of the Transactions of the St. Louis
:ademy, 1873, and not much to the "Notes on *Agave*," illus-
ted by photographs, included in the same volume and pub-
hed in 1875.

Less difficult as respects the material to work upon, but well adapted for his painstaking, precise, and thorough handling, were such genera as *Juncus* (elaborately monographed in the second volume of the Transactions of the St. Louis Academy, and also exemplified in distributed sets of specimens); *Euphorbia* (in the fourth volume of the Pacific Railroad Reports, and in the Botany of the Mexican Boundary); *Sagittaria* and its allies; *Callitriche; Isoetes* (of which his final revision is probably ready for publication), and the North American *Loranthaceæ;* to which *Sparganium*, certain groups of *Gentiana*, and some other genera, would have to be added in any complete enumeration. Revisions of these genera were also kindly contributed to Dr. Gray's Manual; and he was an important collaborator in several of the memoirs of his surviving associate and friend.

Of the highest interest, and among the best specimens of Dr. Engelmann's botanical work, are his various papers upon the American Oaks and the *Coniferæ*, published in Transactions of the St. Louis Academy and elsewhere, the results of long-continued and most conscientious study. The same must be said of his persevering study of the North American Vines, of which he at length recognized and characterized a dozen species,—excellent subjects for his nice discrimination, and now becoming of no small importance to grape-growers, both in this country and in Europe. Nearly all that we know scientifically of our species and forms of *Vitis* is directly due to Dr. Engelmann's investigations. His first separate publication upon them, "The Grape Vines of Missouri," was published in 1860; his last, a reëlaboration of the American species, with figures of their seeds, is in the third edition of the Bushberg Catalogue, published only a few months ago.

Imperfect as this mere sketch of Dr. Engelmann's botanical authorship must needs be, it may show how much may be done for science in a busy physician's *horæ subsecivæ*, and in his occasional vacations. Not very many of those who could devote their whole time to botany have accomplished as much. It need not be said, and yet perhaps it should not pass unrecorded, that Dr. Engelmann was appreciated by his fellow-botanists both at home and abroad, that his name is upon the rolls of most of the societies devoted to the investigation of nature, that he was "everywhere the recognized authority in those departments of his favorite science which had most interested him," and that, personally one of the most affable and kindly of men, he was as much beloved as respected by those who knew him.

More than fifty years ago his oldest associates in this country—one of them his survivor—dedicated to him a monotypical genus of plants, a native of the plains over whose borders

ng immigrant on his arrival wandered solitary and dis-
ed. Since then the name of Engelmann has, by his
earches and authorship, become unalterably associated
e Buffalo-grass of the plains, the noblest Conifers of the
Mountains, the most stately Cactus in the world and
st of the associated species, as well as with many other
f which perhaps only the annals of botany may take
. It has been well said by a congenial biographer, that
estern plains will still be bright with the yellow rays of
nnia, and that the splendid Spruce, the fairest of them
h bears the name of Engelmann, will still, it is to be
over with noble forests the highest slopes of the Rocky
ins, recalling to men, as long as the study of trees occu-
ir thoughts, the memory of a pure, upright, and labo-
e."

II. Oswald Heer.

LD HEER, the most eminent investigator of the fossil
nd insects of the Tertiary period, died on the 27th of
er last, shortly after he had entered upon the seventy-
r of his age.

as born at the hamlet of Nieder-Utzwyl, in Canton St.
Switzerland, August 31, 1809, passed most of his youth
in Canton Glarus, where his father was the parish cler-
pursued his academic and professional studies at the
ity of Halle, and was ordained as minister of the Gospel
ear 1831. The next year he went to Zurich, where he
for the rest of his life. Here he studied medicine for a
it soon devoted himself seriously to entomology and
of which he was fond from boyhood. In 1834 he
Privat-docent of these sciences; in 1852, when the
ity of Zurich was developed, he became its Professor of
and in 1855 he took a similar chair in the Polytechni-
Most of his earlier publications were entomological;
as by the way of entomology that he entered upon his
ished career as a paleontologist. His life-long friend,
ent Escher von der Linth, appreciating his rare powers
vation, induced him to undertake the study of the
ects of the celebrated Tertiary deposits of Oeningen.
ults of his labors in this virgin field were published
the years 1847 and 1853. His attention had from the
en attracted to the plants associated with the insect
. His first paleo-botanical paper appeared in 1851;
e volumes of his *Flora Tertiaria Helvetiæ* were issued
1855 and 1859; in 1862 his memoir on the fossil flora
y-Tracey (England) was published in the Philosophical
tions of the Royal Society, London. About the same

time also appeared a paper, in the Journal of the Geological Society, on certain fossil plants of the Isle of Wight. For the benefit of his health, always delicate and then much impaired, he passed the winter of 1854–55 in Madeira, and on his return published a paper on the fossil plants of that island, and an article on the probable origin of the actual flora and fauna of the Azores, Madeira, and the Canaries. In this and in his work, published in 1860, on Tertiary Climates in their Relation to Vegetation (which the next year appeared also in a French translation by his young friend Gaudin), Heer brought out his theory of a Miocene Atlantis. His more extensive and popular treatise upon past climates as illustrated by vegetable paleontology, his *Urwelt der Schweiz*,—a vivid portraiture of the past of his native country,—appeared in 1865, and afterwards in a revised French edition, with his friend Gaudin (who died soon after) for collaborator as well as translator. There was also an English translation by Heywood, published in 1876, and, indeed, it is said to have been translated into six languages.

In 1877 Heer completed his *Flora Fossilis Helvetiæ*, a square-folio volume with seventy plates, which extended and supplemented his Tertiary Flora of that country, being devoted to the illustration of the fossil plants of the Carboniferous, the Triassic, the Jurassic, and the Cretaceous, as well as the Eocene formations.

The life-long delicacy of Heer's health prevented his making any extensive explorations in person. But materials for his investigation came to him in even embarrassing abundance, not only from his own country,—where, even before he was widely known (as his fellow countryman and his distinguished fellow worker in paleo-botany, Lesquereux, informs us), a lady opened upon her property, near Lausanne, quarries and tunnels expressly for the discovery and collection of fossil plants, and sent them by tons to Zurich,—but from all parts of the world collections were pressed upon him, and his whole time and strength were given to their study. In this way he became interested in the Arctic fossil flora, of which he became the principal investigator and expounder. His first essay in the domain which he has made so peculiarly his own was in a paper on certain fossil plants of Vancouver Island and British Columbia, published in 1865; and in 1868 he brought out the first of that most important series of memoirs upon the ancient floras of Arctic America, Greenland, Spitzbergen, Nova Zembla, Arctic and Subarctic Asia, etc.; which, collected, make up the seven quarto volumes of the *Flora Fossilis Arctica*. The seventh volume of this monumental work was brought to a conclusion only a few months before the author's death.

eer's researches into the fossil botany of the tertiary deposits
e very important in their bearings. They made it certain
our actual temperate floras round the world had a com-
birth-place at the North, where the continents are in prox-
y ; they essentially identified the direct or collateral ances-
of our existing forest trees which flourished within the
tic zone when it enjoyed a climate resembling our own at
ent ; and they leave the similarities and the dissimilarities
he temperate floras of the Old and the New World to be
lained as simple consequences of established facts. Thus
r himself did away with his own hypothesis of a continen-
Atlantis by bringing to light the facts which proved that
e was no need of it. And, while thus justifying the ideas
ch had been brought forward in one of the Memoirs of the
erican Academy (in 1859) before these fossil data were
wn, he was not slow to adopt and to extend the tentative
ws which he had confirmed.*

list of Heer's scientific publications is given in the Botan-
es Centralblatt, No. 5, for 1884. They are seventy-seven
umber, besides the seven quarto volumes of the *Flora Fos-
Arctica*, which comprise a considerable number of inde-
dent memoirs. These works make an era in vegetable
eontology. Their crowning general interest is, that they
ng the vegetation of the past into direct connection with the
sent.

Although he lived to a good old age, and was never inactive,
er was for most of his life an invalid, suffering from pulmo-
ry disease. For the last twelve years his work was carried
at his bedside or from his bed, assisted by a devoted and
omplished daughter ; he seldom left his house, except to
s the last two winters in the milder climate of Italy. Last
nmer, having finished his Arctic Fossil Flora, in the hope of
ruiting his exhausted strength he was removed to the most
ltered spot on the shores of the lake of Geneva, but without
efit. He died at Lausanne, at his brother's house, on the
h of September, 1883. It has been well said of him, in a
ute which a personal friend and fellow naturalist paid to his
mory, that "a man more lovable, more sympathetic, and a
more laborious and pure, one could scarcely imagine."

Heer was elected into the American Academy in May, 1877.
is botanically commemorated in a genus of beautiful
lastomaceous plants, indigenous to Mexico.

The first and second volumes of the *Flora Fossilis Arctica* appeared in 1868—
"Sequoia and its History," in which the writer's earlier view was extended
l made clearer, and Heer's results noted, was published in 1872.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS AND CHEMISTRY.

1. *The diffusion of Gases and Vapors.*—A. WINKELMANN has examined the formulas of Meyer and Stefan in order to see if they agree with carefully conducted observations. His work included observations upon the diffusion of steam; the calculation of the quotients of the diffusion coefficients; the comparison of these with the values derived from O. E. Meyer's results; the calculation of the diffusion coefficients from the observations; results upon the diffusion of ether vapor and of alcohol vapor. The apparatus consisted of a tube, the lower end of which was drawn out into a uniform tube of much narrower bore than the upper portion. This lower portion was graduated. It contained the liquid which was to be vaporized in the gas which was passed over it by an entrance and exit tube led into the wider and upper part of the tube.

For the diffusion of steam in hydrogen, in carbonic acid and in air, Winkelman finds discrepancies between the results given by Meyer's formula and those given by observation. For alcohol vapor in hydrogen, in carbonic acid and in air, and also for ether vapor in hydrogen, carbonic acid and air, a fair agreement is found with results given by Stefan's formula. It also appears that the length of the path of the molecule of the vapor can be at least approximately obtained from Stefan's formula.—*Annalen der Physik und Chemie*, No. 5, 1884, pp. 1–31. J. T.

2. *Atmospheric Electricity.*—The conference of electricians held last April at Paris has called forth various treatises on atmospheric electricity. Among these is a pamphlet entitled Continuous Observations on Atmospheric Electricity made at Florence by Professor Antonio Ròiti. The author discovered that the zero of Mascart's electrometer changed from time to time and believes that this change was due to the use of sulphuric acid as the inner coating of the charging Leyden jar. He accordingly substituted for the bifilar cocoon suspension of Mascart's electrometer a very fine silver wire which served to suspend and also to charge the electrometer needle. In this way he dispensed with the Leyden jar, and found the modified apparatus sufficiently stable. The pamphlet of Professor Ròiti contains a diagram of the electrical observatory planned and occupied by him. He also appends specimens of the curves which represent the changing electrical potential of the air. He is doubtful of the value of simultaneous observations of atmospheric electricity unless great care is taken to eliminate local disturbances.—*Pubblicazioni del R. Istituto di Superiori Pratici e di Perfezionamento di Firenze.* 1884.

Another brochure on the subject of Atmospheric Electricity by igi Palmieri has been translated into German by Heinrich scher. Professor Palmieri has conducted electrical observa- ns on Mt. Vesuvius for many years, and entertains views on : subject of atmospheric electricity which differ from those nerally entertained by other physicists. He believes that the ctricity of the air is not conducted to water droppers and to tal conductors in the air but affects these conductors by induc- n. He does not believe that the Thomson water dropper in nnection with a Mascart electrometer affords a true indication the state of the atmosphere. An observation on the electrical ate of the atmosphere should always be accompanied by obser- ations on the state of the sky with respect to clouds and with spect to humidity. The loss from poor insulation in connection ith apparatus for continuous registration of atmospheric elec- icity is also insisted upon as an argument against the employ- ent of present methods. Professor Palmieri therefore urges e employment of a simple electrometer strongly resembling hat of Peltier and the sudden elevation of a metal conductor in he air through a definite distance of a few feet. The pamphlet f Heinrich Discher contains diagrams of Professor Palmieri's pparatus, and is published by A. Hartleben, Vienna, Pest, eipzig, 1884. J. T.

3. *Earth Currents.*—A number of telegraph lines, above round and also subterranean, have lately been put at the disposal f M. E. E. Blavier, Inspector-General to the Minister of Posts nd Telegraphs of France, in order to study earth currents. Some f the results of this study were submitted to the conference f Electricians held in Paris in April last. The method of pho- ographic registration was adopted. A clock lowered a piece of elatino-bromide paper upon which was received the image of a lit of a lamp reflected from the mirrors of three galvanometers. he latter were connected with three different telegraphic lines unning in different directions. The aperiodic galvanometer of M. Marcel Deprez and D'Arsonval was employed: and large esistances were intercalated between the earth electrodes. These esistances were as high as 10,000 ohms. The observations were egun last September and have been continued with few inter- uptions to the present time. Curves for a complete lunar onth, from February 28th to March 28th, 1883, are also given. o complete discussion of the curves is made; but the study of I. Blavier is evidently the most complete and systematic that as been undertaken of earth currents. If similar observations ould be undertaken over extended areas in different countries ur knowledge of the change of electrical potential at different oints of the earth's surface would be much increased.—*Etudes es Courants Telluriques*, par E. E. Blavier, Paris, 1884. J. T.

4. *Results of the Electrical Congress of* 1884.—At the Elec- rical Congress held last April in Paris the various values of the hm in terms of a column of mercury one millimeter in section

were tabulated. The results obtained by the different methods, expressed in centimeters, were as follows:

B. A.	106·21
Weber (I)	106·14
Kirchhoff	105·93
Lorenz	106·19
Weber (II)	105·47
Joule	106·2[illegible]

The mean of these determinations is 106·02. The Congress decided to recommend a column of pure mercury 106 centimeters in length and one square millimeter in section at the temperature of freezing as the ohm.

The light emitted from a square centimeter of platinum at the temperature of fusion was adopted as the standard of light; and it was requested that observations on earth currents made in different countries be sent each year to the International Bureau of Telegraph Administration at Berne. J. T.

5. *A Manual of Chemistry, Physical and Inorganic*, by HENRY WATTS, B.A., F.R.S. 595 pp. 8vo. Philadelphia, 1884: (P. Blakiston, Son & Co.)—This volume, by the author of the invaluable Dictionary of Chemistry, has many excellent features and will be found a valuable guide by students who are commencing their chemical studies. The general arrangement is in some respects unusual. The leading principles are first very briefly stated in a dozen introductory pages, and then the student is led off to Physics and introduced to the fundamental laws and facts of physical science, more especially as related to Chemistry. This portion of the work makes about one-fifth of the whole and is treated with sufficient fullness to be of substantial value. After having mastered it the student is in a much better position to go forward with the study of chemistry proper. The non-metallic chemical elements are then taken up in the usual order and their properties stated with some detail, after which a digression is made to chemical philosophy, and the subjects of chemical combination, atomicity, quantivalence, etc., hinted at in the introduction, are explained at length with considerable fullness of illustration. Finally, the chemical elements are returned to and taken up in succession from the alkali metals through to the metals of the platinum group. A vast deal of information is condensed into a comparatively small space in this discussion of the chemical elements, and, as was to be expected, the work throughout is fully up to the times. A companion volume on the Chemistry of Carbon Compounds, or Organic Chemistry has also been published by the same author.

II. GEOLOGY AND NATURAL HISTORY.

1. *The Origin of Crystalline Rocks*; by T. STERRY HUNT. (Abstract, by the Author, of a paper read before the Royal Society of Canada, at Ottawa, May 21, 1884.)—The author began by

arking that the problem of the origin of those rocks, both tified and unstratified, which are made up chiefly of crystal- silicates, is essentially a chemical one. He then proceeded review the dispute between the vulcanist and the neptunist ools in geology, as to whether granite and other crystalline ks were formed by igneous or by aqueous agencies, and wed from recent writers that the controversy is not yet led. He noticed, of the igneous school, both the plutonic and volcanic hypotheses of the origin of these rocks, and then con- ered the so-called metamorphic and metasomatic hypotheses, ich would derive them by supposed chemical changes from terials either of igneous or of aqueous origin. The hypothesis Werner was next discussed. This conceives all such rocks to e been successively deposited in a crystalline form from a otic watery liquid which surrounded the primitive earth, and, an early time, held in solution the whole of the materials of se rocks. The inadequacy of all of these hypotheses was inted out, though it would appear that Werner's was the one arest the truth.

The author conceives that the crystalline rocks were formed by position from waters which successively dissolved and brought m subterranean sources the mineral elements. Their formation illustrated by that of granitic veins, and that of zeolites,—pro- sses regarded as survivals of that which produced the earlier cks. The true zeolites are but hydrated feldspars, while the inerals of the pectolite group correspond to the protoxyd-sili- tes of the ancient rocks. The sources of the elements in these cks, according to the new hypothesis here proposed, was in the perficial layer which was the last-congealed portion of an igne- s globe, consolidating from the center. In this primitive ratum, porous from contraction, and impregnated with water, sting upon a heated anhydrous nucleus, and cooled by radia- on, an aqueous circulation would be set up, giving rise to ineral springs. The waters of these dissolved and brought to e surface, there to be deposited, the quartz, the feldspars, and her mineral silicates, which through successive ages built up e great groups of crystalline stratified rocks, often so markedly ncretionary in aspect. Exposed portions of the primitive sili- ted material would be subject to atmospheric decay and disin- gration, giving rise to sediments of superficial origin, which ould become intercalated with the deposits from subterranean urces. The reactions between the mineral solutions from below d the superficial materials were important in this connection, obably giving rise to certain common micaceous minerals,— hile dissolved silicates allied to pectolite, by their reaction with e magnesian salts, which then passed into the ocean-waters, nerated species like serpentine and pyroxene.

This process of continued upward lixiviation of the primitive aotic stratum would result in the production of a great over- ing body of stratified acidic rocks, leaving below a basic, residual and much diminished portion, the natural contraction of which would cause corrugations of the superincumbent stratified mass, such as are everywhere seen in these ancient rocks.

The source of volcanic rocks is partly in this lower and more or less exhausted stratum of comparatively insoluble and basic ferriferous silicates, whence come melaphyres and basalts;—partly in the secondary or acidic mass, which, softened by the combined agency of water and heat, may give rise to granitic and trachytic rocks;—and partly, also, it is conceived, in later aqueous deposits of superficial origin, which, also, may be brought within the influence of the central heat.

This attempt to explain the genesis of crystalline rocks by the continued solvent action of subterranean waters on a primitive stratum of igneous origin, the author designates the *crenitic* hypothesis, from the Greek, *κρήνη*, a spring or fountain. A preliminary statement of it was made by him to the National Academy of Sciences at Washington, April 15, 1884, and appears in the American Naturalist for June.

2. *Alaska glacier phenomena.*—Mr. Thomas Meehan, after an examination of portions of Alaska glaciers, states (Proceedings Acad. Nat. Sci. Philad., 1883, 249) that beneath the Muir glacier, which had been described as 400 miles long, the subglacial stream was a large and rapid torrent, being, according to his estimate, 100 feet wide and 4 feet in average depth; and that he learned from others that the flow was the same winter and summer. The glacier at its termination hung over the sea, and gave off icebergs, because of the movement of the tides, or from the gravity of overhanging portions, or through the detachment of portions by erosion due to running surface water. He shows how the subglacial stream may have become dammed by the moraine deposits and the torrent thus diverted, so as to make large drift deposits in sections of the country far away from the glacier. He remarks that the great icebergs had their lakes, rapids, water-falls, hills and valleys; that the water-ways changed their courses at times through the melting; that melting was in free progress where the sun struck, but not on the shady side of the berg.

3. *Fauna of the St. John Group (Primordial or Cambrian), New Brunswick;* by G. J. Matthew (Trans. Roy. Soc. Canada, 1882).—Treats of the remains of Paradoxides, and especially of the successive forms dependent on age of individuals in the species, *P. eteminicus* and *P. Acadicus*, here described by the author.

4. *Calcium Phosphate, or apatite, of the Canadian rocks.*—Mr. H. G. Vennor has an article in the Canadian Mining Review of January last, in which he shows that the phosphatic material or apatite occurs in a series of irregular masses of varying size, distributed along one or two planes of bedding; they run in the direction of the bedding, and, as the beds are generally upturned at a high angle, they may descend to great depths; but nowhere do they lie in veins. The containing bed consists usually of pyroxene, hornblende, and feldspar, with calcite, the apatite, and

more or less of pyrite. This bedded condition may be observed at the mines of Ottawa County, and in the Rideau section toward Perth and Kingston in the Province of Ontario.

5. *North Carolina Phosphates;* by W. B. PHILLIPS. 20 pp. 16mo.—This pamphlet gives an account of the phosphatic deposits recently discovered in Eastern North Carolina. The situation is somewhat similar to that of the phosphatic deposits of South Carolina, but as at present explored, of much less importance. The material has been found in the counties of Duplin, Brunswick, Pender and others, but not yet directly on the sea-board, and nowhere in sufficient amount to give full assurance of economical importance. The pamphlet, which purports to be a report especially on the Duplin County beds, states that the best opened localities in this county occur 4 to 8 miles north of east of Magnolia. The phosphatic material is found in sand deposits, constituting in places a thin irregular bed 8 to 12 inches thick, along ditches, dry runs and branches, and along their sides at a depth below the surface of the ground from 3 to 5 feet.

6. *Krystallographische Untersuchungen an homologen und isomeren Reihen.* Eine von der Kais. Akademie der Wissenschaften in Wien mit dem A. Freiherrn von Baumgartner'schen Preise gekrönte, durch einen methodologischen Theil vermehrte, Schrift von Dr. ARISTIDES BREZINA. I Theil, Methoden, 359 pp. 8vo. Vienna, 1884 (Carl Gerold's Sohn).—This memoir, which has been awarded the Baumgartner prize by the Vienna Academy, is a profound work dealing with the methods of crystalline determination, including the measurement of crystals, describing the instruments employed and discussing the various kinds of errors; also the methods of projection and calculation. The whole is carried through with almost too much fullness of detail and supplemented by many pages of important formulas.

7. *Cyperus.*—The first part of the 21st volume of the Journal of the Linnean Society is an elaborate essay by CHARLES BARON CLARKE, on the *E. Indian Species of Cyperus* (of 200 pages and with four plates), in which the greater part of the North American species are also considered. It will be found worthy of particular attention. The paper was partially prepared at Kew, but was finished at Calcutta.

We received at the same time a paper in the Transactions of the Linnean Society on *The Cyperaceæ* of West Coast of Africa in the Welwitsch Herbarium, by HENRY L. RIDLEY, of the Botanical Department in the British Museum, with two plates. Of seventy-one species of *Cyperus*, a dozen are found in America, but not in Asia; and so are fifteen other *Cyperaceæ*. A. G.

8. *Alphonse Lavallée.*—In the June number of this Journal (p. 494), we briefly reviewed the new work by Lavallée on the large-flowered Species of Clematis. We had recently received a letter from him, written on the 19th of April, in which he explains that certain oversights at the close of his volume were left uncorrected because an illness had prevented his reading the last

proof sheet, but that his health was now "completely reëstablished." On the third of May this excellent man died, at the age of 49. Our former notices of the *Arboretum Segrezianum* and of the other works he was engaged in may give some faint idea of the irreparable loss which botanical science (especially in relation to the investigation of ornamental trees and shrubs) has now so unexpectedly sustained. We hope to give a proper biographical memorial in due season. A. G.

9. *Chorizanthe, R. Brown: Revision of the genus and rearrangement of the Annual Species*; by C. C. PARRY. Extr. Proceedings of Davenport Academy of Natural Sciences, vol. iv, pp. 45–62. 8vo. 1884.—As this memoir was communicated to the Davenport Academy on the 25th of January, two or three weeks after Dr. Engelmann's death, and was completed within a few days of that sad event, it is appropriately and "mournfully" dedicated to the memory of his old friend.

Dr. Parry has paid great attention to this group of plants and has enjoyed unusually full means of investigating them in their native habitats. He has given a full account of the general structure of the genus, and has added two new species, besides referring to it Remy's genus *Lastarriæa.* To do this he is obliged to take the herbaceous perianth as an involucre and to reckon either that there is no perianth or that it is adnate completely to the involucre; so that the stamens are borne on the throat of an involucre! We much prefer the ordinary and obvious interpretation and should keep up *Lastarriæa.* A. G.

10. *Siliceous spicules of Sponges.*—Mr. J. Thoulet has examined the structure and other characters of the spicules of various sponges collected during the last cruise of the Talisman. They were separated by treating the sponge with hydrochloric acid. The acicular spicules lost 13·18 per cent of weight on heating to redness for ten minutes in a platinum crucible. Before the blowpipe they were whitened, or became slightly ochreous in color, without a trace of fusion. Stellate spicules of five rays lost 12·86 per cent on calcination. The specific gravity, obtained by flotation in a solution of iodides, was 2·032. But the spicules have a delicate tube along the center generally less than ·001 millimeter in diameter; and allowing for this, the author obtained, by calculation, 2·0361 as the true specific gravity—which is that of opal.

The spicules are easily attacked by different chemical agents, so that they ought to be very readily dissolved in sea-water on the death of the animal. They were analyzed after calcination by Boricky's process, by means of pure hydrofluoric acid, after first boiling in nitric acid and calcining, and they were proved to be pure silica. When not previously calcined, but simply washed, the process yielded a residue of hydrofluosilicate of soda in hexagonal prismatic crystals, the origin of which it is hard to explain unless it be that the minute tube of the spicules contains sea-water.—*Bull. Soc. Min. de France*, April, 1884.

11. *A Course of Instruction in Zootomy* (*Vertebrata*); by

EFFERY PARKER, B.Sc.Lond. 397 pp. 8vo, 74 illustrations.
don: Macmillan & Co., 1884.—This work certainly succeeds
s aim to be a continuation of the zoological part of Huxley
Martin's Elementary Biology, and in many ways is an im-
vement upon that very useful pioneer among books of this
s. It gives directions for dissecting and examining the Lam-
, Skate, Cod, Lizard, Pigeon, and Rabbit—an excellent selec-
of readily obtainable forms. The paragraphs giving direc-
s for each stage of the dissection are followed by careful
riptions of the structures brought into view, and in many
s the descriptions are illustrated by good figures in the text, a
minent and excellent feature of the book, which supplies a
t long felt by those giving laboratory instruction in vertebrate
tomy. S. I. S.

2. *Handbook of Vertebrate Dissection;* by H. NEWELL MAR-
, D.Sc., M.D., M.A., and WILLIAM A. MOALE, M.D. Part
, How to Dissect a Rodent. 86 pp. 8vo, 6 illustrations. New
rk: Macmillan & Co., 1884.—This covers essentially the same
und as the last chapter of the work just noticed, and, on super-
al examination, does not compare favorably with it. The ani-
l chosen, the rat, seems a less favorable subject for dissection
n the rabbit, is not so fully described as is the latter by Prof.
rker, and the few illustrations given are all of the skull, which
less in need of illustration than the brain and some other parts;
t the work will be very useful when a short time only is allowa-
for the dissection and a small animal desirable, or when the
bit is not readily procurable. S. I. S.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Lawrence Smith medal of the U. S. National Academy.*—
ce the death of Dr. J. Lawrence Smith, Mrs. Smith has gen-
usly given to the National Academy the sum of eight thous-
d dollars (being the proceeds of the sale of Dr. Smith's
llection of meteorites to Harvard,) the income from which is to
used for a "Lawrence Smith Medal." The following are
ations from the deed of trust, with a few verbal changes:

The medal shall be awarded from time to time by the National
ademy of Sciences to any person in the United States, or else-
ere, who shall make an original investigation of meteoric
dies the results of which shall be made public, and shall be in
opinion of the Academy of sufficient importance and benefit
science to merit such recognition, provided, however, that said
dal shall not be awarded more frequently than once in two
rs, and provided also that the investigation for which it is
arded or the completed publication thereof shall have been
de since the time of the last preceding award of the said
dal.

f investigations of equal importance shall be made in regard to meteoric bodies at or about the same time in the United States of America, and also in some other part of the world, each of which might in the opinion of the Academy entitle the investigator to be considered as a competitor for the medal, preference shall be given in the awarding thereof to investigations made by a citizen of the United States.

If at any time or times the interest and income of the trust-fund of eight thousand dollars shall exceed the amount necessary for the striking of said medal, and the care of the said die and of the fund, the surplus shall be used in such manner as shall be selected by the National Academy of Sciences, in aid of investigations of meteoric bodies to be made and carried on by a citizen or citizens of the United States of America.

The deed of trust and the acceptance of the fund by the Academy bears the date of the 6th of May, 1884, and the signatures of Mrs. Smith, and the President of the Academy, Professor O. C. Marsh.

2. *American Association for the Advancement of Science.*—The meeting of the American Association at Philadelphia will open on Thursday, the 4th of September (not Wednesday, the 3d, as stated on page 479), at 10 o'clock, in the Academy of Music, on Broad street. Members who intend to be present are desired to notify early the Local Committee that arrangements may be made, as it is probable that the attendance will be very large. A map and guide-book is being prepared by this committee for the members. The offices of the Permanent Secretary and Local Committee will be at the Academy of Music after September 1, and previous to this time at the Academy of Natural Sciences. The Permanent Secretary will establish his office in Philadelphia on August 22d. Titles of papers to be presented should be early sent to the Permanent Secretary, with a statement of the time the reading will require. According to the rules of the Association, no title will be referred by the Standing Committee to a Sectional Committee until an abstract of the paper, or the paper itself, has been received; and no paper will be read until it has been placed on the programme of the day by the Sectional Committee.

3. *International Geological Congress, Third Session.*—The third session of the International Geological Congress will open at Berlin on the 25th of September next, under the presidency of Dr. H. von Dechen. The sessions will end on the 30th, and be followed by excursions from the 1st to the 5th of October. The names, place of residence, etc., of geologists intending to be present should be sent to the Secretary of the Committee of Organization at Berlin, N., 44 Invalidenstrasse (Bergakadamie). The membership fee is twelve francs, and can be remitted in advance with the request to be enrolled among the members. Professor Beyrich is president of the Committee of Organization, and Professor Hauchecorne, General Secretary.

4. *Life History Album*, by FRANCIS GALTON, F.R.S., Chair

an of the Life-History sub-Committee.—The pages of this thin olume are blank forms, with directions and lists of heads, to aid e individual owning a copy to enter all the facts relating to his wn physical characteristics and conditions through successive ears or periods, and those of children or others dependent on im, so that a permanent record may be made for scientific eductions. It is issued under the direction of the Collective nvestigation Committee of the British Medical Association. he volume has been prepared with great skill, and the putting t into general use is greatly to be desired.

A second similar volume is arranged for especially a "*Record f family faculties.*" These volumes are published by Macmillan & Co., London.

OBITUARY.

ROBERT ANGUS SMITH (of Manchester, Eng.)—There are certain trees, like the Rock Maple of the New Hampshire hill sides, and the "Pasture Oak" of our ship-wrights, which attain a highly useful development when left to grow by themselves. Far from craving support and shelter from their kindred, or needing to be pushed or crowded into view through conflict with their compeers, they can hold out to grow most vigorously and symmetrically in the open. Doubtless some loss as to mere height is a necessary consequence of the independent habit of growth; but for practical purposes the loss is more than made good by increase of breadth and toughness. Such trees can be clearly seen, withal, because they are not in the woods.

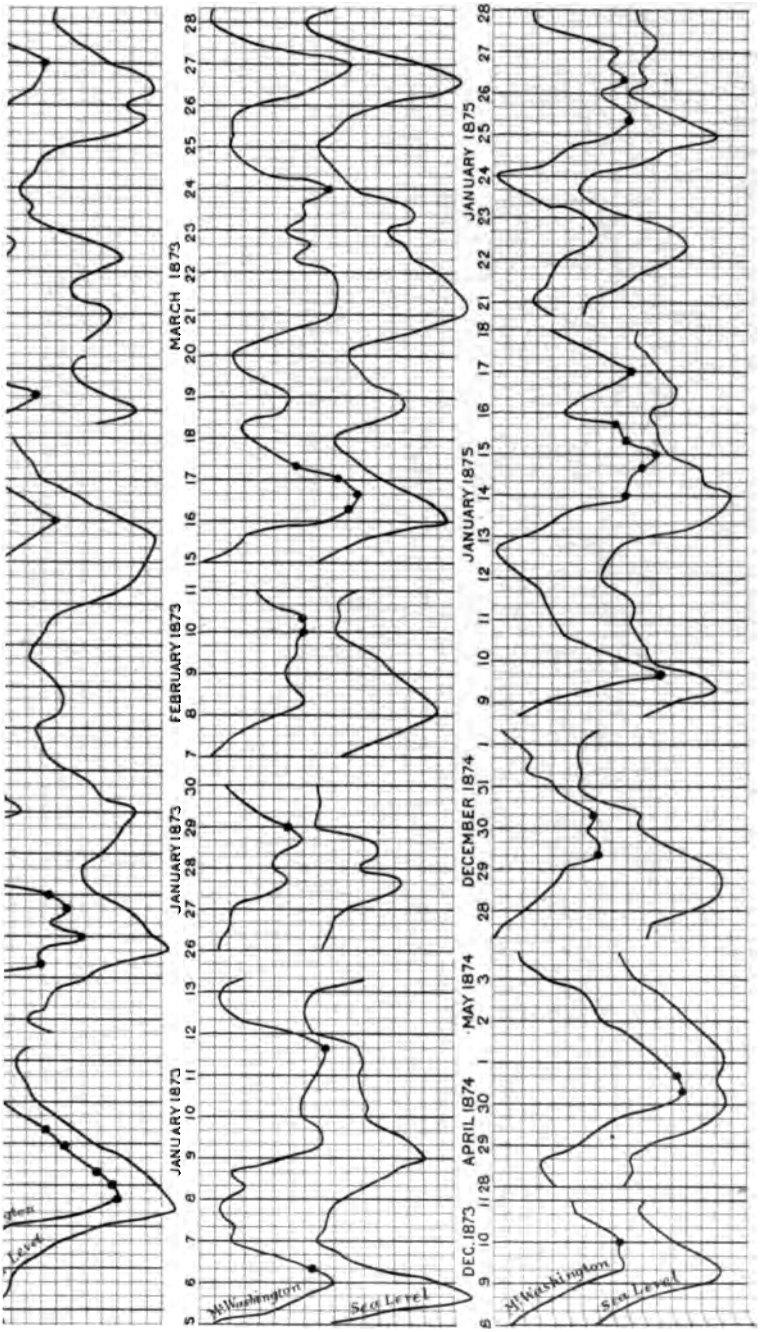
In like manner, there appear occasionally in the outlying fields of science solitary or, so to say, detached men, who attain to stature and proportions which claim the most respectful attention of their contemporaries. It is characteristic of such men that they command success, no matter how isolated their position may be, or how completely they are separated from the crowd of common workers. To all appearance, they stand in small need of prestige or assistance, such as public position or academic chairs may give. And it would almost seem as if the very absence of outside help and of close communion with their fellows did but work for good by heightening their own individuality and inducing peculiar lines of thought which finally take full possession and become part and parcel of them. In the history of Chemistry there are several familiar examples of men who, without ever themselves making any specially brilliant discovery, or taking conspicuous part in investigations and controversies which have determined the reception of one or another class of theoretic views and conceptions, have nevertheless become eminent by sheer force of character, sagacity, and sound common sense. In this category the name of Angus Smith may most properly be placed. He possessed in high degree the sterling qualities just enumerated, together with abundant knowledge; a capacity for long-continued, painstaking, minute research; and absolute trustworthiness; and it was by virtue of these attributes that he impressed himself very emphatically on the Chemistry of his day and generation. Although never, we believe, actually occupied as a teacher of chemistry, in the narrow sense of the word, he had none the less great influence as a master, here in America as well as in Europe. Indeed he long held rank as one of the most prominent chemists of Great Britain, and was acknowledged as a standard authority, the more especially in matters relating to the application of scientific knowledge to acts of legislation, particularly as regards sanitary affairs and the conduct of mines and manufacturing establishments. His researches on air, and rain, and water are well-known and widely esteemed: he himself called them at one time "the beginnings of a chemical climatology." So too are his publications on disinfectants, sewage, the air of mines, ventilation, and a variety of other subjects. Since 1863, he has done his country and humanity good service, and the cause of science as well, in his official capacity as Inspector-General of alkali works,—an office which was perhaps created for him to fill, and for the proper filling of which it may well be said that he was specially created.

Previous to the act of 1863, there had been for a generation or two a bitter feud between the soda manufacturers of Glasgow, Newcastle, and Lancashire, and those of their neighbors who, having no immediate pecuniary benefit from the works, found their fields and their families poisoned by the fumes of muriatic acid, which in those regions costs more to save than it is worth. It is safe to say that no more difficult task could be presented to a man of scientific habit of thought, accustomed to entertain conscientious scruples, than that of composing differences such as these in such manner that while the sanitary requirements of the neighborhoods should be protected or made good, no injustice should be done, in the pecuniary sense, to the owners of the gigantic manufacturing establishments or their work-people. The prudent, conciliatory, judicious, and effective—because just and wise—manner in which this most intricate problem was treated by Smith is above all praise. The conduct of the matter, as set forth in his annual "Reports under the Alkali Act," may well be studied by American statesmen as affording a most striking and instructive contrast to some of our own so-called sanitary acts of legislation and administration, notably those which have recently become notorious as disgracing all sense of justice and intelligence in one of our leading States.

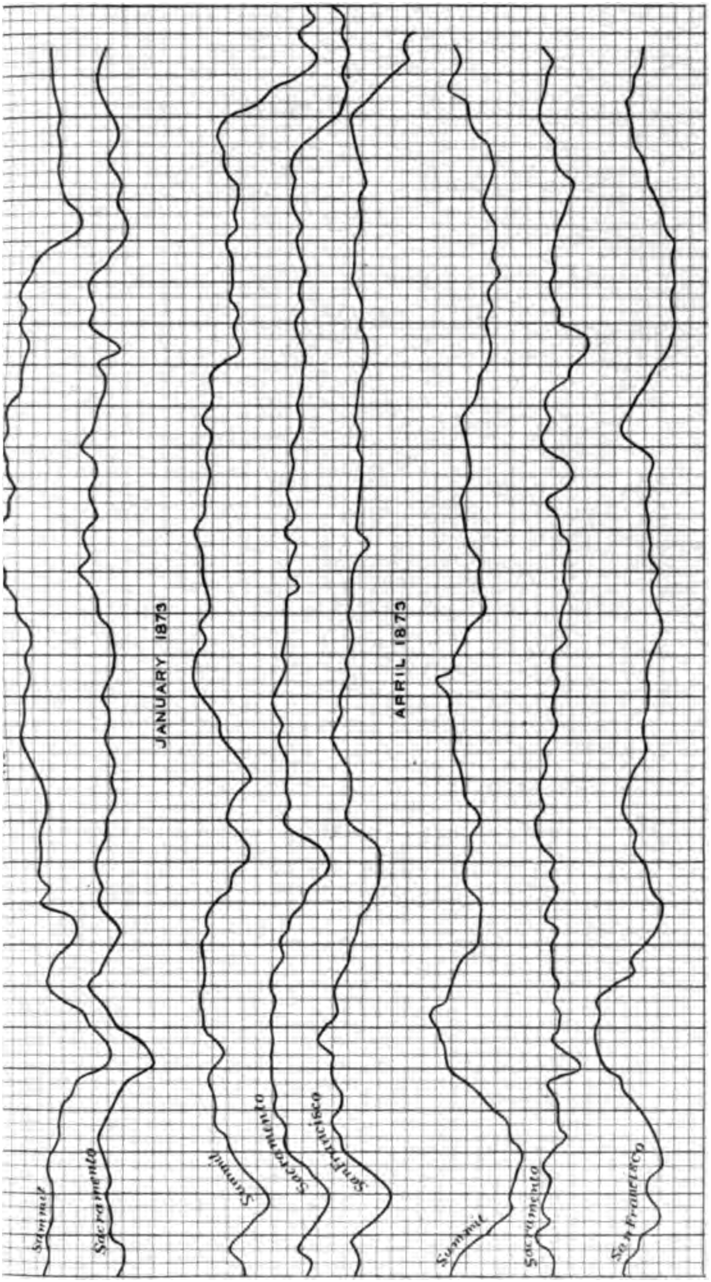
Many American chemists and physicists must still remember the feeling of sympathy and good will with which they received some years since, the goodly volume entitled "Chemical and Physical Researches of Thomas Graham," which was prepared, and printed, and distributed by Angus Smith and James Young, as a tribute to the memory of their old friend and master. It was, indeed, in every sense a most worthy monument.

Dr. Smith was born in 1817 near Glasgow. He died May 11th, at Colwyn Bay near Llandudno, after an illness of several months' duration. F. H. S.

BAROMETRIC FLUCTUATIONS. PLATE 1.



BAROMETRIC FLUCTUATIONS. PLATE 2.



THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

RT. XIII.—*Contributions to Meteorology*; by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Twentieth paper.

[Continued from page 17.]

Reduction of Barometric observations to sea-level.

I next proceeded to make a similar comparison of the obser- tions at Summit station and Sacramento in California. hese observations, which are in manuscript, were again loaned e by Prof. J. D. Whitney. Table VIII shows the principal rometric minima at Summit during a period of three years, d table IX shows the principal barometric maxima at Sum- it during the same period. The hours of observation were A. M., 2 and 9 P. M. and these hours are indicated by the num- als 1, 2 and 3.

The numbers in each of these tables were arranged in the rder of the mean temperatures, and divided into four equal roups, and the average of the numbers in each group was ken. The results are given in the first five columns of table II, and the numbers in the following columns were computed the manner already explained for Mt. Washington. These esults for barometric minima accord well with those for Pike's eak; but for barometric maxima the differences between the bserved reductions from Summit to Sacramento, and those com- uted by Ferrel's formula, are three times as great as for Mt. Vashington, and more than twice as great as for Pike's Peak. portion of this difference is unquestionably due to an error n the assumed mean temperature of the air column. This is hown by the observations at Colfax. For the California Jeteorological observations, Prof. Whitney selected three sta- ions, Sacramento, Colfax and Summit; the first station being levated 31 feet above sea-level; the second 2425 feet and the hird 7017 feet. These three stations are nearly in a straight ine, and Colfax is nearly equidistant from the other two sta- tions. The table at the bottom of the next page shows the mean temperature of each station for each month of the year.

AM. JOUR. SCI.—THIRD SERIES, VOL. XXVIII, NO. 164.—AUG., 1884.

TABLE VIII.—*Barometric minima at Summit, Cal.*

No.	Date.	Sacramento.		Summit.		Mean temp.	No.	Date.	Sacramento.		Summit.		Mean temp.
		Bar.	Ther.	Bar.	Ther.				Bar.	Ther.	Bar.	Ther.	
	1870.							1872.					
1	Oct. 15.3	29·755	63°	23·090	32°	47°·5	39	Feb. 4.3	29·956	58°	22·952	29·5	43°·7
2	23.1	·818	39	22·941	22	30·5	40	24.1	·560	46	·634	28·5	37·2
3	26.1	·774	41	·941	23	32	41	Mar. 5.2	·922	56	23·055	32	44
4	Nov. 6.2	·810	59	·898	35	47	42	11.2	·954	57	·008	30	43·5
5	26.2	·957	63	23·069	39	51	43	28.3	·876	57	·055	33	45
6	Dec. 2.2	·744	57	22·956	35	46	44	Apr. 6.1	·965	49	22·966	22	35·5
7	5.3	·866	44	·904	21	32·5	45	16.1	·825	46	·923	30	38
8	15.2	·928	46	·979	22	34	46	27.1	·975	49	23·028	28·5	38·7
	1871.						47	May 7.3	·815	53	22·929	30	41·5
9	Jan 10.1	·892	46	·918	26·5	36·2	48	14.1	·856	61	23·068	31	46
10	17.3	·924	45	23·058	32	38·5	49	Jun 16.1	·885	57	·062	48	52·5
11	23.2	·919	53	·054	30	41·5	50	Au. 19.2	·835	72	·199	57	64·5
12	28.2	30·049	56	·063	29	42·5	51	Sept. 2.3	·779	59	·077	43·5	51·2
13	Feb 10.2	29·957	55	·053	33·2	44·1	52	22.3	·942	54	·119	36	45
14	15.2	·882	45	22·921	27	36	53	Oct. 21.3	·905	54	·135	47	50·5
15	22.1	·585	37·5	·613	14	25·7	54	26.2	30·033	61	·142	32	46·5
16	Mar. 6.3	30·035	53	23·016	28·5	40·7	55	Nov. 8.2	29·886	62	·005	53	57·5
17	13.1	29·874	41	22·894	23	32	56	23.2	·967	57·5	·136	45	51·2
18	17.1	30·099	46	23·074	20	33	57	Dec 24.2	·925	53	·035	34	43·5
19	22.1	·029	38	·063	23	30·5	58	28.2	·686	53	22·959	35	44
20	Apr. 6.1	29·857	47·5	22·912	23	35·2	59	30.2	·873	54	23·041	36	45
21	16.3	·597	44	·727	21	32·5		1873.					
22	23.3	·859	67	23·096	29·5	48·2	60	Jan. 3.1	·933	49	·035	33	41
23	M'y 17.2	·883	68	·069	38·5	53·2	61	13.1	30·227	48	·151	30	39
24	28.3	·821	52	22·928	25	38·5	62	30.2	29·803	62	22·703	20	41
25	Jun 24.1	·902	54	23·184	43	48·5	63	Feb. 1.2	·652	44	·751	32	38
26	Jul. 26.3	·778	64	·165	49·5	56·7	64	8.3	·790	47	·905	32	39·5
27	Sep. 28.1	·908	52	·088	31	41·5	65	16.2	·969	57	·896	21	39
28	Oct. 27.3	·944	53·5	·165	31	42·2	66	18.1	·953	37	·914	18	27·5
29	Nov. 3.3	·957	52	22·993	28	40	67	24.1	·559	39	·593	24	31·5
30	11.2	·852	58	·940	24	41	68	27.1	·998	42	·977	25	33·5
31	26.2	·771	53	·705	27	40	69	Mar. 5.3	30·007	52·5	·917	28	40·2
32	28.3	·925	44	·973	23	33·5	70	26.1	·065	48	23·121	33	40·5
33	Dec 17.3	·785	47	·841	21	34	71	Apr. 4.1	·109	61	22·908	21	41
34	21.2	·543	50	·698	28	39	72	25.2	·101	67	23·088	49	58
35	23.1	·665	37	·700	29	33	73	M'y 15.1	29·941	55	·003	32	43·5
36	29.2	·751	54	·863	32	43	74	22.2	·971	78	·049	60	69
	1872.						75	28.1	·948	59	·005	30	44·5
37	Jan. 9.2	·875	47	·888	32	39·5	76	Jun 24.2	30·032	70·5	·051	41	55·7
38	24.1	·967	38	23·031	14·5	26·2							

Mean temperature of Sacramento, Colfax and Summit.

	Sacramento.	Colfax.	Summit.	Temp. excess.		Sacramento.	Colfax.	Summit.	Temp. excess.
January	47°·1	48°·1	29°·2	2°·02	July	73°·7	79°·8	61°·0	5°·23
February	48·8	44·3	27·3	1·35	August	71·3	78·5	59·1	5·69
March	54·8	51·6	31·6	2·38	September	67·4	71·0	53·6	4·16
April	59·3	54·1	33·8	1·77	October	60·2	63·2	46·3	3·88
May	65·5	63·9	43·9	2·90	November	50·8	52·0	34·3	3·43
June	70·9	73·4	54·9	3·99	December	45·4	47·2	29·1	3·69

TABLE IX.—*Barometric maxima at Summit, Cal.*

Sacramento.		Summit.		Mean temp.	No.	Date.	Sacramento.		Summit.		Mean temp.
Bar.	Ther.	Bar.	Ther.				Bar.	Ther.	Bar.	Ther.	
						1872.					
29·957	55°·5	23·469	51°·5	53°·5	46	Jan 17.3	30.260	47°·5	23·490	27°	37°·2
30·019	52·5	·470	48	50·2	47	22.1	·332	42	·522	24	33
·204	47·5	·635	45	46·2	48	Feb. 6.2	·254	51	·336	30	40·5
·262	39	·451	26·5	32·7	49	17.3	·137	58	·370	34·5	46·2
·137	42·5	·499	35·5	39	50	19.2	·187	55	·360	33	44
·276	53	·643	37·5	45·2	51	Mar. 2.1	·376	47	·480	28·5	37·7
·290	43·5	·601	35	39·2	52	6.3	·292	52	·385	28·5	40·2
·218	53	·514	35·5	44·2	53	13.2	·321	56·5	·391	28	42·2
·191	50	·375	24	37	54	Apr 11.2	·296	60	·338	31	45·5
·316	28·5	·348	9	18·7	55	22.2	·093	76	·457	45	60·5
·384	37	·455	20·5	28·7	56	30.3	·146	66	·522	39	62·5
·300	36·5	·533	32·5	34.5	57	M'y 17.1	·033	67	·399	53	60
					58	23.1	·065	71	·453	46	58·5
·279	34	·540	22	28	59	Jun. 9.1	29·901	65	·466	56	60·5
·367	36·5	·475	14·8	25·6	60	21.3	·929	78	·530	50	64
·213	39	·403	28	33·5	61	Au. 21.3	·910	72	·458	57	64·5
·376	36·5	·453	15·7	26·1	62	Sep 11.1	·988	67	·529	51	59
·191	38	·355	28·5	33·2	63	14.1	·998	68	·557	59	63·5
·225	48	·344	20	34	64	Oct. 10.1	30·052	54	·533	46	50
·325	34·5	·387	20	27·2	65	17.1	·063	53	·520	50	51·5
·376	48	·531	28	38	66	Nov. 6.1	·312	41·5	·591	35	38·2
·265	58	·445	23	40·5	67	18.1	·513	40	·695	26	33
·303	63·5	·399	40	51·7	68	20.1	·145	39	·584	35	37
·131	69·5	·358	47	58·2	69	Dec. 3.3	·243	46	·460	33	39·5
·216	51	·483	28	39·5	70	6.1	.017	57	·447	25	41
·146	57	·349	28	42·5	71	10.1	·165	37	·499	28	32·5
·245	49	·466	38	43·5		1873.					
·077	72	·344	49	60·5	72	Jan. 9.1	·246	48	·477	27	37·5
29·924	62·5	·357	49	55·7	73	15.3	·224	49	·536	35	42
30·022	68	·361	60	64	74	19.1	·243	42·5	·530	33	37·7
29·974	73·5	·438	59	66·2	75	Feb. 5.2	·499	56	·521	28	42
·948	71	·493	74	72·5	76	11.3	·331	50·5	·347	33	41·7
30·085	89	·537	71	80	77	21.3	·039	50	·494	22	36
29·946	90	·495	75	82·5	78	Mar. 2.1	·451	36	·512	18	27
·994	66	·531	62	64	79	9.3	·213	57	·416	36	46·5
·896	79	·537	64	71·5	80	18.1	·089	50	·427	27	38·5
·878	88	·520	74	81	81	Apr. 7.2	·070	73	·550	38	55·5
30·142	64	·552	47	55·5	82	15.2	·071	76	·515	51	63·5
·086	42	·479	38·5	40·2	83	May 6.1	29·778	42	·344	43	57·5
·116	64	·548	49	56·5	84	31.1	30·087	63·5	·382	38	50·7
·250	40	·419	23	31·5	85	Jun 17.1	·066	68·5	·492	52	60·2
·425	40	·662	30	35	86	28.1	·180	64	·446	50	57
·373	45	·579	23	34	87	Jul. 19.2	29·792	103	·489	70	86·5
·413	40·5	·526	32	36·2	88	27.3	·864	86	·534	70	78
·331	37	·663	31	34	89	Au. 20.1	30·084	54	·472	40	47
					90	24.2	29·882	81	·419	47	64
·228	51	·412	36	43·5							

e assume that the mean temperature of the air column n Sacramento and Colfax is equal to the half sum of the atures at those stations, and similarly for the air column n Colfax and Summit, then the mean temperature of the entire column between Sacramento and Summit will exceed the half sum of the temperatures at those two stations, by the quantities shown in column fifth of the above table. The differences of pressure due to these errors of temperature for the four lines in table III for barometric maxima at Summit, are

−·036; −·037; −·053 and −·044.

Subtracting these numbers from the numbers in column eleventh of table III the differences are

−·287; −·185; −·102 and −·007,

which are the discrepancies between theory and observation remaining to be explained; so that twenty-three per cent of the discrepancies appear to be due to the error in the assumed temperature of the air column. In about half of the cases, the barometric maxima occurred at Sacramento at the same time as at Summit (that is, within eight hours of the same instant). In two thirds of the remaining cases, the maxima occurred first at Sacramento, so that the second cause appears to have only a slight influence at Summit. The main cause for these discrepancies appears to be the small range of the barometer at Sacramento, and the frequent want of correspondence between the barometric fluctuations at the two places. The following table shows, in decimals of an inch, the mean range of the barometer at Summit and Sacramento for each month as derived from the observations of three years.

	Summit	Sacra'to	Su.–Sa.		Summit.	Sacra'to	Su.–Sa.
January	[illegible]	[illegible]	[illegible]	July	0·317	0·369	—0·052
February	[illegible]	[illegible]	[illegible]	August	[illegible]	·329	— ·033
March	[illegible]	[illegible]	[illegible]	September	[illegible]	·405	— ·051
April	[illegible]	[illegible]	[illegible]	October	[illegible]	·525	— ·015
May	[illegible]	[illegible]	[illegible]	November	[illegible]	·647	— ·150
June	[illegible]	[illegible]	[illegible]	December	[illegible]	·709	— ·011

[illegible] mean monthly range of the [illegible] greater at Summit than at Sacramento, [illegible] mean pressure at [illegible] Sacramento [illegible] would exceed the [illegible]

[illegible] at these stations are [illegible] The accompanying [illegible] barometer at Summit [illegible] Nov. 1877 and Jan. [illegible] I have added the [illegible] Signal Service [illegible] there is a marked [illegible] the three prinipal fluctuations, but the minor fluctuations at the two stations bear but little resemblance to each other, and the entire barometric range for the month at Sacramento is only two-thirds of that at Summit. The resemblance between the curves at Summit and Sacramento for Jan., 1873, is not quite as great, and the entire range for the month at Sacramento is less than two-thirds of that at Summit. The curve for San Francisco accords better with that at Summit than does the curve at Sacramento, and the range of the barometer is greater. For the month of April, 1873, there is not a single point of resemblance between the curves at Sacramento and Summit, and the entire range of the barometer at Sacramento is only 54 per cent of that at Summit At San Francisco, on the contrary, in the large fluctuations, the barometric curve shows considerable resemblance to that at Summit, and the range of the barometer is almost as great. These facts seem to furnish the clue to the anomalous character of the barometric observations at Sacramento. Sacramento is situated in a valley between two ranges of mountains. On the east are the Sierra Nevadas, 7000 feet in height, and on the southeast they rise to the height of 10,000 to 12,000 eet. On the west side, is the Coast Range of mountains, rising o the height of 3,000 to 4,000 feet, with a gap about fifty miles wide, through which flows the Sacramento river. From he summit of the Coast Range to the summit of the Sierra Nevadas, is but little more than 100 miles. In this valley of the Sacramento it is not possible that there should be much cyclonic motion of the winds. The winds at Sacramento almost always blow up or down the valley, and the winds from the three directions W., E. and N.E. form only eight per cent of the entire number for the year. The marked resemblance between the curves at San Francisco and Summit for the larger barometric fluctuations, seems to indicate that the cyclonic motion of the winds at San Francisco is sometimes propagated obliquely upward to the summit of the Sierra Nevadas, and in such cases it sometimes leaves no sensible trace of its influence at Sacramento. This comparative freedom of the air at Sacramento from cyclonic and anti-cyclonic disturbance, appears to be the chief cause of the anomalies noticed when we compare the observations at Summit and Sacramento. The value of the pressure coefficient which best satisfies the observations at Summit and Sacramento is 60449 and that of the temperature coefficient is $\frac{1}{1000}$.

I next proceeded to make a similar comparison of observations made at Grand St. Bernard and Geneva. As the Bibliothèque Universelle de Genève only gives the daily averages of the observations for 1877–9 (the observations employed in my fifteenth paper) I selected the years 1858, '59 and '60 for which the observations are published in full for four hours each day, viz: 8 A. M., noon, 4 and 8 P. M. Table X shows the principal barometric minima at Grand St. Bernard during this period of three years, and table XI shows the principal barometric max-

TABLE X.—*Barometric minima at Grand St. Bernard.*

No.	Date.	Geneva.		Gr. St. Bernard.		Mean temp.	No.	Date.	Geneva.		Gr. St. Bernard.		Mean temp.
		Bar.	Ther.	Bar.	Ther.				Bar.	Ther.	Bar.	Ther.	
	1858.							1859.					
1	Jan. 5.1	726·56	— 4·6	556·75	—15·2	— 9·9	47	M'y 15.1	717·91	- 8·0	555·95	— 4·9	- 1
2	21.3	23·48	- 0·7	53·20	—15·9	— 7·6	48	Jun. 2.4	17·98	—13·1	59·97	- 1·0	- 7
3	Feb. 2.2	25·86	- 3·1	54·83	—18·7	— 7·8	49	10.1	18·20	—14·9	59·80	- 1·5	- 0
4	7.4	25·33	— 0·4	57·04	—12·9	— 6·65	50	Au. 31.3	22·55	—18·6	61·03	— 2·2	- 0
5	16.1	20·13	- 0·4	55·25	—10·3	— 4·95	51	Sep 17.1	13·22	—12·3	53·70	— 0·1	- 6
6	22.3	19·89	- 1·8	57·52	—13·3	— 5·75	52	Oct. 21.4	08·67	—12·8	52·26	— 1·0	- 5
7	Mar. 1.1	13·29	— 0·8	50·09	— 9·6	— 4·5	53	23.4	15·49	— 0·4	52·27	— 3·0	— 1
8	7.1	09·68	— 5·6	41·07	—20·3	—12·95	54	29.4	13·97	— 9·2	54·60	— 3·6	+ 2
9	12.1	21·83	0·0	51·80	—1[illegible]	— 8·45	55	Nov. 4.4	14·62	— 6·5	59·31	— 3·3	+ 1
10	15.1	18·1[illegible]	- 3·1	51·70	—1[illegible]·2	— [illegible]	56	17.2	25·48	— 4·4	58·44	—12·0	— 3
11	Apr. 1.3	14·40	- 12·1	53·8[illegible]	— 3·[illegible]	- 4·5	57	Dec. 2.1	12·[illegible]	— 1·2	45·33	—15·6	— 7
12	11.3	17·7[illegible]	- [illegible]	55·43	— 2·[illegible]	- [illegible]	58	15.3	16·43	— 4·4	45·14	—21·6	—13
13	27.3	21·8[illegible]	—12·[illegible]	[illegible]	— [illegible]	- [illegible]	59	19.4	16·2[illegible]	— 4·9	45·69	—18·5	—11
14	May 3.2	[illegible]	- 7·2	[illegible]	— [illegible]	- [illegible]	60	28.2	[illegible]	- 4·[illegible]	47·69	— 6·5	— 0
15	9.1	[illegible]	- 4·4	[illegible]	— 7·4	— [illegible]		1860.					
16	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	- [illegible]	61	Jan. [illegible]	[illegible]	- 7·6	47·79	— 5·0	+ 1
17	23.2	[illegible]	[illegible]	[illegible]	— [illegible]	- [illegible]·5	62	[illegible]	[illegible]	- 9·2	50·26	—11·9	— 3
18	[illegible]	[illegible]	[illegible]	[illegible]	- [illegible]	- [illegible]	63	[illegible]	[illegible]	- 4·[illegible]	4[illegible]·10	—11·7	— 3
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	- [illegible]	64	[illegible]	[illegible]	- 5·[illegible]	47·61	— 8·2	— 1
20	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	- [illegible]	65	Feb. [illegible]	[illegible]	- [illegible]	[illegible]·41	—14·2	— 6
21	[illegible]	[illegible]	[illegible]	[illegible]	- [illegible]	[illegible]	66	[illegible]	[illegible]	— [illegible]	4[illegible]	—15·8	— 8
22	Oct. [illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	- [illegible]	67	[illegible]	[illegible]	— 4·[illegible]	[illegible]	—19·7	—12
23	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	— [illegible]	68	[illegible]	[illegible]	— [illegible]	44·45	—1[illegible]·7	— 7
24	Nov. [illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	— [illegible]	69	[illegible]	[illegible]	— [illegible]	[illegible]	— 7·0	— 0
25	[illegible]	[illegible]	[illegible]	[illegible]	—	—	70	Mar. [illegible]	[illegible]	- [illegible]	[illegible]	—1[illegible]·3	— 4
26	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	- [illegible]	71	[illegible]	[illegible]	— [illegible]	[illegible]	— [illegible]	—13
27	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	- [illegible]	72	[illegible]	[illegible]	— [illegible]	[illegible]	—11·2	— 5
28	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	- [illegible]	73	[illegible]	[illegible]	- [illegible]	[illegible]	— [illegible]·5	— 3
29	Dec. [illegible]	[illegible]	[illegible]	[illegible]	—	— [illegible]	74	[illegible]	[illegible]	- [illegible]	[illegible]	— [illegible]	- 6
30	[illegible]	[illegible]	[illegible]	[illegible]	—	— [illegible]	75	[illegible]	[illegible]	- [illegible]	[illegible]	— 7·5	- 1
31	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	- [illegible]	76	[illegible]	[illegible]	- [illegible]	[illegible]	—[illegible]	— 5
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	77	[illegible]	[illegible]	- [illegible]	[illegible]	— 7·4	— 1
32	[illegible]	[illegible]	[illegible]	[illegible]	—	— [illegible]	78	[illegible]	[illegible]	- [illegible]	[illegible]	— [illegible]·2	- 5
33	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	— [illegible]	79	[illegible]	[illegible]	- [illegible]	[illegible]	- [illegible]	—13
34	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	[illegible]	80	[illegible]	[illegible]	- [illegible]	[illegible]	- [illegible]	—10
35	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	81	[illegible]	[illegible]	- [illegible]	[illegible]	— [illegible]	- 1
36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	82	[illegible]	[illegible]	- [illegible]	[illegible]	— [illegible]	— 0
37	Mar. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	83	[illegible]	[illegible]	- [illegible]	[illegible]	—[illegible]	— 6
38	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	84	[illegible]	[illegible]	- [illegible]	[illegible]	—[illegible]	— 4
39	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	85	[illegible]	[illegible]	- [illegible]	[illegible]	— [illegible]	— 2
40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	86	[illegible]	[illegible]	- [illegible]	[illegible]	— [illegible]	— 0
41	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	87	[illegible]	[illegible]	- [illegible]	[illegible]	— [illegible]	— 0
42	[illegible]	[illegible]	[illegible]	[illegible]	—	—	88	[illegible]	[illegible]	- [illegible]	[illegible]	— [illegible]	— 3
43	[illegible]	[illegible]	[illegible]	[illegible]	—	—	89	[illegible]	[illegible]	— [illegible]	[illegible]	—[illegible]	— 8
44	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	90	[illegible]	[illegible]	— [illegible]	[illegible]	—[illegible]	— 8
45	Mar. [illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	91	[illegible]	[illegible]	— [illegible]	[illegible]	—[illegible]	—12
46	[illegible]	[illegible]	[illegible]	[illegible]	—	—	92	[illegible]	[illegible]	— [illegible]	[illegible]	—[illegible]	— 9

during the same period. The hours of observation are cated by the numerals 1, 2, 3 and 4.

he numbers in each of these tables were arranged in the r of the mean temperatures, and divided into four equal ps as explained in the preceding cases. The first five col- s of table III show the average results, and the numbers e following columns were computed in the manner hereto-

TABLE XI.—*Barometric maxima at Grand St. Bernard.*

Geneva.		Gr. St. Bernard.		Mean temp.	No.	Date.	Geneva.		Gr. St. Bernard.		Mean temp.
Bar.	Ther.	Bar.	Ther.				Bar.	Ther.	Bar.	Ther.	
						1859.					
39·90	— 3°8	573·76	— 0°6	— 2°2	43	M'y 11.1	726·62	+15°3	566·22	+ 4°2	+ 9°75
36·19	— 2·0	69·34	— 6·7	— 4·35	44	Jun. 7.2	26·39	+21·5	68·73	+ 8·5	+15·0
36·81	— 2·6	67·72	—11·7	— 7·15	4[illegible]	23.3	29·92	+25·8	71·94	+ 8·4	+17·1
38·08	— 5·7	67·83	— 8·8	— 7·25	46	27.2	30·39	+25·5	74·56	+14·7	+20·1
30·17	+ 3·0	64·75	— 7·6	— 2·3	47	July 3.4	30·00	+24·0	76·85	+15·3	+19·65
31·89	+ 0·8	66·97	— 7·6	— 8·4	48	13.2	32·26	+25·7	75·34	+14·4	+20·05
33·19	+ 3·7	67·42	— 6·6	— 1·45	49	Aug. 4.1	28·48	+24·6	73·50	+12·1	+18·35
35·91	+ 9·8	71·62	+ 2·2	+ 6·0	50	12.2	27·92	+22·4	71·31	+10·8	+16·6
28·11	+ 6·5	64·93	— 4·3	+ 1·1	51	Sep 10.2	29·80	+23·6	70·89	+10·9	+17·25
27·24	+10·1	65·23	— 3·5	+ 3·3	52	26.1	32·89	+14·3	74·41	+ 9·1	+11·7
30·26	+14·4	69·99	— 2·9	+ 5·75	53	Oct. 2.2	34·38	+21·5	74·98	+ 8·2	+14·85
30·63	+15·8	71·14	+ 2·4	+ 9·1	54	17.4	28·16	+11·9	68·24	+ 1·5	+ 6·7
30·91	+17·2	70·36	+ 8·7	+12·95	55	Nov. 6.4	29·82	+13·7	70·59	+ 3·9	+ 8·8
27·01	+22.9	69·78	+ 7·1	+15·0	56	13·4	33·82	— 0·8	68·13	— 6·9	— 3·85
32·10	+20·2	73·75	+ 9·9	+15·05	57	19·2	34·27	+ 0·3	68·66	— 0·6	— 0·15
27·00	+23·0	72·47	+ 8·8	+15·9	58	26·4	29·17	+ 0·6	66·45	— 4·0	— 1·7
30·27	+21·4	71·99	+ 6·4	+13·9	59	Dec. 9.2	37·88	+ 1·6	70·58	— 0·8	+ 0·4
29·72	+23·6	73·44	+ 8·3	+15·95	60	31.3	32·96	+ 9·4	69·08	— 1·9	+ 3·75
28·86	+22·1	72·28	+ 7·5	+14·8		1860.					
30·84	+20·2	71·84	+10·1	+15·15	61	Jan. 9.1	38·00	— 5·5	71·16	— 5·3	— 5·4
30·42	+16·6	72·72	+ 4·5	+10·55	62	16.4	34·33	+ 1·4	68·50	— 5·8	— 2·2
31.87	+18·9	73·71	+ 6·8	+12·85	63	Feb. 5.1	33·33	— 6·5	64·14	— 8·4	— 7·45
32·71	+17·8	72·61	+ 6·8	+12·3	64	7.4	34·80	— 0·6	63·08	—15·5	— 8·05
30·96	+ 9·0	70·98	+ 2·0	+ 5·5	65	25.4	33·06	— 0·9	65·53	— 9·6	— 5·25
32·58	+ 7·9	71·19	+ 3·6	+ 5·75	66	Mar. 4.1	36·39	— 1·7	66·85	— 9·0	— 5·35
33·73	— 4·0	67·27	— 7·0	— 5·5	67	6.3	35·64	+ 1·2	63·70	—15·6	— 7·2
32·37	+ 0·2	66·19	— 7·4	— 3·6	68	20.2	33·73	+ 6·8	67·66	— 5·2	+ 0·8
33·43	— 2·0	67·14	— 7·9	— 4·95	69	Apr. 6.1	23·63	+ 8·9	62·13	— 2·5	+ 3·2
31·94	+ 4·5	66·59	— 4·7	— 0·1	70	16.4	28·04	+ 9·8	65·26	— 4·0	+ 2·9
					71	30.2	29·38	+10·2	67·07	+ 0·6	+ 5·4
44·25	— 6·2	73·60	— 8.2	— 7·2	72	M'y 11.2	27·74	+18·0	69·89	+ 4·5	+11·25
36·35	0·0	69·36	— 9.9	— 4·95	73	21.2	30·53	+20·8	69·70	+ 5·8	+13·3
36·93	— 2·0	70·21	— 9.8	— 5·9	74	Jun 26.2	27·94	+29·2	72·32	+13·4	+21·3
36·91	+ 9·3	70·71	— 1.9	+ 3·7	75	Jul. 3.2	33·16	+19·5	71·53	+ 7·3	+13·4
35·69	— 0·9	67·75	— 6.5	— 3·7	76	Au. 19.4	31·45	+14·9	70·16	+ 4·9	+ 9·9
35·33	+ 5·6	69·71	— 2.5	+ 1·55	77	26.4	26·32	+22·0	71·58	+11·5	+16·75
36·09	+11·2	73·03	+ 3·0	+ 7·1	78	Sep 22.2	30·18	+16·6	70·39	+ 7·5	+12·05
34·23	+17·8	70·90	— 0·8	+ 8·5	79	Oct. 3.2	35·49	+13·5	70·56	+ 0·4	+ 6·95
33·53	+ 7·0	67·83	— 5·8	+ 0·6	80	7.2	35·00	+11·2	72 80	+ 7·0	+ 9·1
33·25	+ 9·6	71·89	+ 0·7	+ 5·15	81	21.2	32·98	+12·0	70·82	+ 6·9	+ 9·45
29·49	+17·8	71·06	+ 3·0	+10·4	82	26.4	32·36	+ 8·6	70·77	+ 1·0	+ 4·8
27·51	+13·1	68·24	+ 1·9	+ 7·5	83	N'v 29.2	25·38	+ 4·6	65·91	— 2·4	+ 1·1
25·79	+12·2	65·24	+ 0·3	+ 6·25	84	Dec 29.4	35·10	— 3·6	64·99	—15·5	— 9·55

fore explained. In tables X and XI the pressures are given in millimeters and the temperatures in centigrade degrees; but for convenience of comparison, the results in table III are given in English units. The results for barometric minima accord well with those for Pike's Peak and Summit, but for barometric maxima the observed values differ from the computed values less than for either of the preceding cases. Can these differences be ascribed wholly to the error in the assumed temperature of the air column? In order to decide this question, I have examined the observations made by Plantamour at several stations in the neighborhood of Mt. Blanc and published in Mémoires de la Société de Physique de Genève, volume xv, pp. 399–403. The following table gives a summary of the results.

Station.	Altitude meters.	No. of Obs.	Thermometer.			M. temp. — ½ sum.
				Geneva.	St. Ber.	
Serraval............	840	22	16°·41	17°·88	5°·55	+0°·57
Chamouuix	1044	11	12·16	15·89	2·44	+ 0·22
Evoléna............	1379	7	11·63	17·11	2·43	+ 0·73
Bourg St. Pierre ...	1640	22	11·16	17·40	5·52	+ 0·44
Cantine de Proz....	1809	11	12·39	19·24	9·60	— 0·14

Column first gives the name of the station; column second its altitude in meters; column third the number of observations made; column fourth the mean of the observations made at the stations named in column first; columns fifth and sixth the mean of the observations made at Geneva and St. Bernard at the same hours; column seventh shows the difference between the half sum of the temperature at Geneva and St. Bernard and the mean temperature of the air column deduced from the observations in the manner heretofore explained. The mean of the differences in column seventh is 0°·40 Cent. or 0°·72 Fahr. These observations were all made in the months of July, August and September, and the above difference has an algebraic sign opposite to that of the difference in table III for the summer months. If then we apply a correction for the error in the assumed temperature of the air column, we only increase the discrepancies which are to be explained.

The barometric minima at St. Bernard for the three years here employed, occurred on an average 4·7 hours later than at Geneva. St. Bernard is 50 miles east of Geneva and a barometric minimum travels this distance in three hours, so that at St. Bernard the barometric minima appear to be retarded 1·7 hours on account of elevation. The discrepancies shown in table III are to be ascribed partly to this retardation but mainly to the dissimilarity of the barometric curves at the two stations.

value of the pressure coefficient which best satisfies the 'ations at Grand St. Bernard and Geneva is 60300, and f the temperature coefficient is $\frac{1}{960}$.

ext proceeded to make a comparison of observations made lle di Valdobbia and Alessandria. As the Moncalieri in only gives the daily averages of the observations for 79, I selected for examination the years 1879, '80 and '81, iich the observations are published in full for three hours lay (viz: 9 A. M., 3 and 9 P. M.) in the Annali dell Ufficio

ABLE XII.—*Barometric minima at Colle di Valdobbia.*

Alessandria.		C.diValdobbia		Mean temp.	No.	Date.	Alessandria.		C.diValdobbia		Mean temp.
Bar.	Ther.	Bar.	Ther.				Bar.	Ther.	Bar.	Ther.	
						1880.					
746·9	5·8	553·0	— 5·9	— 0·05	41	Sep 16.1	744·4	17·9	557·3	2·5	+10·2
43·6	—2·3	45·4	—15·2	— 8·75	42	Oct. 12.1	49·3	12·7	59·1	0·1	+ 6·4
55 6	—0·2	55 9	— 8·5	— 4·35	43	20.2	47·5	16·8	58·9	2·7	+ 9·75
34·3	6·7	45·2	— 1·7	+ 2·5	44	29.3	42·1	11·4	54·4	— 2·1	+ 4·65
30·2	10·8	44·0	— 6·5	+ 2·15	45	Nov. 3.2	52·0	4·8	57·3	— 9·5	— 2·35
35·1	3·4	41·7	— 8·5	— 2·55	46	17.2	35·4	9·4	47·1	— 1·8	+ 3·8
26·3	1·8	37·0	— 7·9	— 3·05	47	21.3	50·0	7·7	58·6	— 3·5	+ 2·1
30·7	1·7	40·2	— 7·7	— 3·00	48	Dec 17.2	50·0	7·5	57·4	— 2·0	+ 2·75
40·5	11·3	51·0	— 2·8	+ 4·25	49	21.2	49·8	5·9	56·7	— 7·2	— 0·65
44·2	9·2	52·6	— 5·3	+ 1·95	50	25.2	43·5	2·2	52·0	— 3·4	— 0·6
38·4	8·8	48·9	— 3·7	+ 2·55	51	31.1	52·2	4·8	57·0	—10·3	— 2·75
38·8	9·0	48·2	— 5·8	+ 1·6		1881.					
38·0	10·2	47·4	— 5·5	+ 2·35	52	Jan 13.3	38·6	1·1	45·3	—11·0	— 5·0
43·5	17·5	54·2	0·7	+ 9 1	53	15.2	40·7	—0·2	44 7	—11·7	— 5·95
41·4	9·3	51·0	— 2·2	+ 3·55	54	20.1	41·6	—6·3	45 7	—14·0	—10·15
46·6	23·5	59·3	3·5	+13·5	55	23.1	49·3	—6·9	51 8	—12·8	—10·35
42·9	21·4	58·5	2·6	+12·0	56	30.1	42·1	0·1	50·8	— 8·3	— 4·1
40·5	10·0	51·3	— 2·2	+ 3·9	57	Feb. 6.1	46·1	—4·0	51·9	— 7·9	— 5·95
42·2	10·8	53·9	- 2·2	+ 4·3	58	9.1	45·1	—6·0	53·0	— 8·7	— 7·35
45·6	9·7	54·6	— 7·6	+ 1·05	59	11.3	35·5	3·0	44·9	— 8·3	— 2·65
47·9	—0·8	53·6	—10·5	— 5·65	60	Mar. 1.2	43·8	7·2	51·6	— 8·6	— 0·7
50·2	1·2	54·1	—11·7	— 5·25	61	22.2	46·2	13·6	52·5	—12·2	+ 0·7
46·1	4·2	51·9	— 9·7	— 2·75	62	25.2	45·3	5·5	52·5	— 1·8	+ 1·85
39·4	1·8	43·4	—15·0	— 6·6	63	30.2	43·4	12·3	55·0	— 0·5	+ 5·9
40·0	—5·6	44·9	—11·6	— 8·6	64	Apr. 3.2	42·0	16·8	54·9	2·4	+ 9·6
					65	5.2	45·7	12·7	56·1	— 0·7	+ 6·0
54·0	-11·1	52·7	—12·4	—11·75	66	20.2	36·2	18·9	50·1	1·5	+10·2
59·0	—4·6	57·7	—13·5	— 9·05	67	22.2	36 9	15·1	48·8	— 3·8	+ 5·65
50·8	1·3	55·8	— 4·9	— 1·8	68	May 3.2	49·1	10·7	58·3	0·3	+ 5·5
48·4	3·3	55·3	— 5·1	— 0·9	69	Jun. 8.1	39·7	15·3	51·4	— 2·8	+ 6·25
45·7	6·8	52·2	— 5·3	+ 0·75	70	Au. 17.2	43·8	20·1	59·1	9·4	+14·75
45·8	8·8	53·8	— 6·2	+ 1·3	71	Sept. 1.2	41·9	15·4	57·0	0·1	+ 7·75
45·5	17·5	56·7	0·0	+ 8·75	72	22.2	43·8	22·4	58·2	4·5	+13·45
49·1	7·3	56·0	— 3·6	+ 1·85	73	Oct. 4.2	47·4	13·2	57·1	0·8	+ 7·0
39·5	7·9	49·7	— 4·8	+ 1·55	74	21.2	43·2	8·0	53·4	— 1·6	+ 3·2
45·4	13·2	56·5	— 2·2	+ 5·3	75	25.2	40·6	12·6	53 9	2·1	+ 7·35
45·5	13·0	55·7	2·6	+ 7·8	76	31.1	44·1	7·3	53·1	— 6·1	+ 0·6
41·0	11·5	53·6	— 1·0	+ 5·25	77	Nov. 2.2	45·7	16·5	56·7	— 0·9	+ 7·8
46·6	11·7	56·1	— 3·0	+ 4·35	78	28.2	54·9	7·4	59·7	— 3·2	+ 2·1
47·0	17·5	59·0	6·2	+11·85	79	Dec 11.2	45·0	1·7	53·9	— 6·0	— 2·15
43·9	20·5	58·4	5·9	+13·2	80	20.2	45·0	3·5	49·9	— 5·5	— 1·0

Centrale di Meteorologia Italiana. Table XII shows the principal barometric minima at Colle di Valdobbia during thi period of three years, and table XIII shows the principal barometric maxima during the same period. The hours of obse vation are indicated by the numerals 1, 2 and 3.

TABLE XIII.—*Barometric maxima at Colle di Valdobbia.*

No.	Date.	Alessandria.		C.di Valdobbia		Mean temp.	No.	Date.	Alessandria.		C.di Valdobbia		M te
		Bar.	Ther.	Bar.	Ther.				Bar.	Ther.	Bar.	Ther.	
	1879.		°		°	°		1880.		°		°	
1	Jan 1.1	759·2	2·0	566·1	— 2·6	— 0·3	47	Au 28 1	756·6	21·1	569·8	8·6	+1
2	13.3	61·1	—3·2	66·2	— 6·5	— 4 85	48	31.3	57·3	19·0	69·9	6·5	+1
3	27.1	59·6	3·9	65·0	— 5·2	— 0·65	49	Sep. 2.3	61·0	20·9	74·7	7·9	+
4	Feb 7.1	54·6	—0·6	61·4	— 5·5	— 3·05	50	Oct. 1.1	61·2	13·3	72·2	2·9	+
5	9.1	56·7	5·9	62·6	— 4·5	+ 0·7	51	15.3	58·5	11·5	67·7	2·6	+
6	Mar. 9.3	65·8	7·7	72·3	— 3·0	+ 2·35	52	Nov 7.3	61·9	8·8	68·9	— 2·4	+
7	17.1	58·0	4·2	63·1	— 3·4	+ 0·4	53	24.3	64·1	8·2	69·5	— 1·8	+
8	Apr. 1.1	55·6	13·5	63·4	— 0·8	+ 6·35	54	29.3	67·3	6·8	73·2	— 1·5	-
9	25.3	49·1	15·9	61·0	— 3·9	+ 6·0	55	Dec. 8.1	67·1	—1·0	74·8	1·0	
10	May 5.3	55·7	14·0	63·5	— 3·1	+ 5·45	56	11.1	55·4	2·2	66·1	— 0·2	-
11	14.3	54·4	14·6	64·0	— 1·0	+ 6·8		1881.					
12	22.3	53·7	16·0	67·6	0·5	+ 8·25	57	Jan. 2.3	64·6	1·8	66·2	—11·7	—
13	30.1	59·7	12·1	66·7	0·5	+ 6·3	58	6.3	58·5	5·9	64·5	— 5·6	+
14	Jn. 11.3	56·0	22·0	70·4	5·9	+ 13·95	59	Feb 3.1	55·9	—5·1	61·7	— 7·7	—
15	21.3	52·3	25·5	68·3	7·4	+ 16·45	60	16 3	57·9	3·0	61·9	— 5·8	—
16	28.2	55·4	30·7	72 5	12·4	+ 21·55	61	21·3	61·4	7·2	65·9	— 4.5	+
17	Jul 25.3	54·8	23·9	70·4	9·4	+ 16 65	62	23·3	60·8	5·5	65·0	— 8·4	—
18	28.3	56·4	23·9	71·5	8·8	+ 16·35	63	Mar.3.1	60·9	0·6	62·9	— 7·5	—
19	Aug 3.1	54·4	26·1	72·4	16·0	+ 21·05	64	9.3	56·2	10·3	66·4	— 2·3	+
20	20.3	53·5	24·7	70·6	11·9	+ 18·3	65	18.3	62·4	10·8	71·5	— 1·0	+
21	29.3	54·7	24·8	71·4	12·3	+ 18·55	66	23.3	57·7	8·7	62·5	— 7·5	+
22	Sep 2.1	59·4	24·5	73·8	12·4	+ 18·45	67	Ap 17.3	54·9	16·3	64 1	— 0·3	+
23	Oct. 8.3	55·9	16·5	70·3	8·3	+ 12·4	68	25.3	55·1	11·6	63·5	— 2·5	+
24	[illegible]	62·1	14·4	72·8	7·0	+ 10·7	69	30.3	57·0	12·1	65·2	— 1·5	+
25	Nov 5.3	62·6	5·7	69·3	— 2·8	+ 1·45	70	May 7.2	61·9	22·4	72·6	8·9	-
26	8.3	63·4	5·7	71·7	1·0	+ 3·35	71	22.1	[illegible]	19·5	69·7	6·8	-
27	[illegible]	[illegible]	3·2	[illegible]	— [illegible]	— [illegible]	72	30.3	[illegible]	[illegible]	67·4	3·5	-
28	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	— [illegible]	73	[illegible] 4.2	[illegible]	[illegible]	[illegible]	6·2	-
29	[illegible]	[illegible]	—[illegible]	[illegible]	— 4·5	— [illegible]	74	[illegible]	[illegible]	[illegible]	[illegible]	6·6	-
30	[illegible]	[illegible]	—[illegible]	[illegible]	— [illegible]	— 6·4	75	[illegible]	[illegible]	[illegible]	[illegible]	10·5	-
	[illegible]						76	[illegible] 4.3	[illegible]	[illegible]	[illegible]	14·3	+
31	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	— [illegible]	77	[illegible]	[illegible]	[illegible]	75·5	15·2	+
32	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	— [illegible]	78	[illegible]	[illegible]	[illegible]	[illegible]	14·4	-
33	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	— [illegible]	79	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-
34	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	80	[illegible]	[illegible]	[illegible]	74·5	9·6	-
35	[illegible]	[illegible]	— [illegible]	[illegible]	— [illegible]	— [illegible]	81	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-
36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	82	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-
37	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	— [illegible]	83	[illegible]	[illegible]	[illegible]	[illegible]	4·0	-
38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	84	[illegible]	[illegible]	[illegible]	[illegible]	10·4	+
39	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	85	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-
40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	86	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-
41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	87	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-
42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	88	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-
43	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	89	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-
44	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	90	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	-
45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	91	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	-
46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]	92	[illegible]	[illegible]	—[illegible]	[illegible]	[illegible]	-

Table III shows the results deduced from these observations in the manner already fully explained, the pressures being expressed in English inches, and the temperatures in degrees of Fahrenheit. These results do not differ very widely from those found for Grand . St. Bernard, but the discrepancies between theory and observation are somewhat greater. The first question then is can these discrepancies be explained by the error in the assumed temperature of the air column? In order to answer this question I have sought for observations of the thermometer at stations intermediate between Colle di Valdobbia and Alessandria and have found two, viz: Biella, elevated 434 meters above the sea, and Cogne, elevated 1543 meters. The following table shows the mean temperatures of the four stations for each month of the year, deduced from the three years 1879–81. The sixth column shows the difference between the mean temperature of the air column and the half sum of the temperatures of the upper and lower stations. The sign + indicates that the former exceeds the latter.

	Aless'a.	Biella.	Cogne.	Valdo'a	Temp. excess.		Aless'a	Biella.	Cogne.	Valdo'a	Temp. excess.
	°	°	°	°	°		°	°	°	°	°
Janu'y	−2·53	−0·43	−6·80	−8·63	+0·58	July ..	24·13	21·37	15·47	9·27	−0·17
Febr'y	2·47	3·50	−3·63	−6·50	+0·31	Aug'st	23·30	20·50	15·10	9·80	−0·38
March	8·37	7·33	+1·10	−2·73	−0·17	Sept. .	18·47	15·97	10·30	5·40	−0·40
April .	12·07	9·87	3·37	−1·63	−0·36	Oct. ..	12·00	11·00	4·83	0·67	−0·04
May ..	15·37	13·20	7·27	+1·40	−0·01	Nov. ..	6·23	5·77	+0·57	−2·83	+0·10
June ..	20·37	17·70	12·00	5·10	+0·11	Dec. ..	−0·03	1·87	−4·27	−6·20	+0·55

This table shows that in winter the mean temperature of the air column is almost 1° Fahr. greater than the half sum of the temperatures of the upper and lower stations, and in summer the former temperature is a little less than the latter; but this error will only explain about ten per cent of the discrepancy between theory and observation shown in table III.

Somewhat more than half of the barometric minima occur at the same hour (i. e. the same hour of observation) both at Colle di Valdobbia and Alessandria. On an average for the three years, the barometric minima occur at Valdobbia three quarters of an hour later than at Alessandria, and allowing for difference of longitude, the actual retardation at Valdobbia is at least three hours. The barometric maxima occur at Valdobbia on an average three and one-half hours later than at Alessandria, and allowing for difference of longitude the actual retardation is about six hours. This will explain a portion of the discrepancies between theory and observation shown in table III, but the principal part is due to the dissimilarity of the barometric curves at the upper and lower stations; i. e. to the dissimilar movements of the upper and lower strata of the atmosphere.

The value of the pressure coefficient which best satisfies the observations at Colle di Valdobbia and Alessandria is 60418 and that of the temperature coefficient is $\frac{1}{1061}$.

It will be noticed that in all of the preceding cases (except California) the error arising from assuming that the mean temperature of the air column is equal to the half sum of the temperatures at the upper and lower stations is quite small. I have endeavored to obtain information relating to the same question from other parts of the world. In the Indian Meteorological Memoirs, vol. ii, p. 135, is given a table showing the vertical decrement of temperature in the Himalaya Mountains for each month of the year at intervals of 1000 feet up to 12,000 feet. From this source I have derived the following table, in which column second shows the mean decrement of temperature for each 1000 feet of elevation for the three winter months, and column third shows the same for the three summer months.

Height in feet.	Winter.	Sum'er.	Height in feet.	Winter.	Sum'er.
0 to 1,000	1°·60	4°·00	4.000 to 5.000	2°·08	3°·57
1.000 to 2.000	1·67	3·98	5.000 to 6.000	2·30	3·30
2.000 to 3.000	1·77	3·91	6.000 to 7,000	2·54	2·97
3,000 to 4.000	1·91	3·77	7.000 to 8.000	2·83	2·59

From these numbers we find that in winter, for an elevation of 8000 feet, the mean temperature of the air column is greater than the half sum of the temperatures of the upper and lower stations by 0°·82 Fahr.; and in summer the former is less than the latter by 0°·94 F. These results are similar to those found for the southern slope of the Alps. The observations in the Sacramento valley make the mean temperature of the air column greater than the half sum of the temperatures at the upper and lower stations at all seasons of the year, but the effect in summer is much greater than in winter. The observations on Mt. Washington and on the northern slope of the Alps indicate an effect for summer similar to that in California, but much smaller in amount.

The average value of the barometric coefficient deduced from the observations at the five stations employed in this investigation, is 60379, and the value of the thermometric coefficient is $\frac{1}{1000}$. Hence the Laplace formula becomes

$$H = 60379 \text{ ft.} \times \log.\frac{B}{B} \times \left(1+\frac{t+t-64}{1000}\right) \times (1+0·002606 \cos 2\,L) \times \left(1-\frac{H+52252}{20886860}+\frac{S}{10443430}\right)$$

The reduced pressures computed from this formula are own in column twelfth of table III, and the differences tween the observed and computed values are shown in the t column. In computing the reductions from Summit to cramento, I have applied to the half sum of the temperatures the upper and lower stations, the corrections shown on page . In the four other cases I have applied no such correction cause this correction appears to be quite small, and its pre-se value is not very well determined. We see that with low essures the computed reduction to the lower station is (with e trifling exception) always too small; but with high press-res the computed reduction is (with two trifling exceptions) lways too great. It has been shown that only a small part of hese differences can be ascribed to the error in the assumption hat the mean temperature of the air column is equal to the alf sum of the temperatures at the upper and lower stations. he discrepancies are mainly due to the dissimilarity in the urves representing the barometric fluctuations at the two tations.

In consequence of this dissimilarity, it happens that when he barometer on the top of a mountain is at a minimum, the arometer at its base is generally not exactly at its minimum, r it is a minimum of an inferior order. The barometer at the ase is therefore higher than it would be if there was an exact orrespondence between the barometric movements at the two tations, and the observed difference between the upper and ower barometers is greater than that which theory would ndicate. On the contrary, when the barometer on the top of he mountain is at a maximum, the barometer at the base is enerally not exactly at its maximum, or it is a maximum of n inferior order. The barometer at the base is therefore ower than it would be if there was an exact correspondence etween the barometric movements at the two stations, and the bserved difference between the two barometers is less than hat which theory would indicate.

Hence we see the utter hopelessness of discovering a formula hich shall exactly represent the barometric reduction to sea-evel at all pressures and temperatures, unless the formula takes ccount of these dissimilar movements in the upper and lower trata of the atmosphere; and since these movements are reatly modified by the obstruction of the mountains upon hich the observations are made, and therefore vary with the cality, such an attempt seems a hopeless undertaking.

ART. XIV.—*Notes on the Rocks and Ore-Deposits in the vicini of Notre Dame Bay, Newfoundland;* by M. E. WADSWORTH.

INTRODUCTORY.

THIS paper has been written for the purpose of presentin some of the results of a short trip to the island of Newfoun land in the summer of 1880. Since the object of the journe was a commercial one in behalf of parties interested in some o deposits about the Notre Dame Bay, the observations and co lections were naturally confined to the immediate vicinity c the mineral lands, and limited as to time.

In the descriptions of the rocks collected the object has bee rather to describe the rock structure and to trace its history, tha to enter upon elaborate descriptions of the contained minerals The principles employed for the nomenclature here given ar those announced in the Bulletin of the Museum of Comparative Zoology, 1879, v, 275–278, and employed in my later petrographical papers.

The key note is the belief that a large portion of the olde rocks now designated by various names were once identical with their modern representatives, and that the present differences of the former from the latter are due chiefly, if not entirely to secondary changes since the time of eruption. The olde rocks are classed as varieties under the modern species whose altered form they are supposed to be, and the mineral compositio is regarded not as a fixed but a changing factor. Hence the traces of the original minerals and of the original structure o rock are here allowed much greater weight in nomenclatur than is given to the secondary or alteration minerals, whic now form the chief mass of these older rocks.

The districts examined were chiefly various points betwee Exploits Burnt Island and Betts Cove.

THE BASALT ROCKS.

Melaphyr (Lava Flows).

Much of the coast of Exploits Burnt Island is formed by a series of lava flows. These flows are seen to have rolled an tumbled over one another down the steep slopes in hug rounded botryoidal and lobe-like masses resembling in thei irregular rocky structure a writhing mass of huge anaconda or a pile of Bologna sausages. A succession of these flow has taken place, the succeeding lava, like heavy tar, slowl tumbling over the preceding flows and building up stee slopes. The lines of motion and the scum-like wrinkling with the few large cells are plainly to be seen, wonderfull preserved. This lava evidently was very pasty, and the flows have a contour and surface that reminds one very strongly of the recent lava flows of the Sandwich Islands. I have no doubt that the eruption was of the same quiet kind, and the lava a basalt of the same character as that now poured forth from Kilauea.

The structure of these lava flows can be well seen at the localities known as Great Lobster Cove, Break Heart Point and Taylor's Nose. At the latter a fissure forming a cave by the sliding of one side of the mass, with the subsequent sea action, admits us into the interior of these flows, where the same structure of a series of pasty flows—one above the other—is to be seen.

The present outline of these slopes was formed by the thick viscid basaltic lavas, the original surfaces of the flows being still preserved. While indeed other flows may have been removed, one thing is certain, the present surface is now the surface of a flow. Not a trace of glaciation could be found, but the fiord-like character of this region seems to be mainly due to the building up of steep slopes by lava, the intrusion of eruptive masses and the jointing and faulting, with or without a change of the relative position of the sea and land. The whole region bordering on Notre Dame Bay has clearly been the theater of tremendous volcanic activity which in part at least is of later date than the graptolite shales. The absence of glacial phenomena is very striking to one used to New England; Signal Head, by the city of St. John's, being the only locality in which any such phenomena were observed by me.

One of the projecting rounded knobs of the above mentioned lava was procured. This is a fine-grained greenish-gray rock weathering brown and holding small porphyritically inclosed crystals of feldspar. The section (860)* is composed of an earthy gray groundmass holding porphyritic feldspars. The groundmass is made up of a dirty gray fibrous and granular mass, formed undoubtedly from the alteration of a glassy or globulitic base, and inclosing numerous minute ledge-formed basaltic plagioclase crystals. Some viriditic or greenish micaceous material of a secondary nature occurs, as well as traces of ferruginous granules derived from the alteration of magnetite grains. A few augite grains together with some pseudomorphs after olivine were observed. Excepting the secondary changes, this lava is in microscopic structure strikingly like that from the eruptions of Kilauea in 1872, the microscopic characters thus supporting the field observations. This rock is here regarded as formed from a viscous glassy lava—a basalt, whose present difference from that of Hawaii is due solely to secondary changes since eruption. In its present state it would be called by most lithologists a melaphyr.

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* The numbers correspond to the numbers of rocks in the Whitney Lithological Collection in the Museum of Comparative Zoölogy.

The same lava flows were seen on the south side of Lawrence Harbor on the main land. The specimen procured is somewhat more altered than the preceding, and contains calcite and dark delessite (?) amygdules, besides some pyrite. In the section the base is more decomposed and the feldspars are in part obliterated by the secondary spherulitic structure induced by alteration, which is here much more strongly marked than in No. 860. A number of pseudomorphs after augite, etc., are composed of quartz grains implanted on the walls and an interior portion of dirty green delessite. One amygdule of the delessite was seen which showed a dirty green aggregately polarizing mass crossed by a band of lighter green fibrously polarizing delessite (?). Delessite and viridite are irregularly scattered through the section and one pseudomorph of the latter after olivine was seen.

Melaphyr (Dikes).

On South West Point of Exploits Burnt Island a number of dark melaphyr dikes were observed. A specimen (865) from one about two feet in width, cutting the diabase and striking north and south, is a brownish black rock with yellowish brown spots of decomposition, which resemble decomposed feldspars. It weathers brown and cellular and contains grains and crystals of augite, magnetite and pyrite.

The brownish section is composed of a dense groundmass of augite microlites, biotite and magnetite, holding larger augites, greenish viriditic and dolomitic pseudomorphs after olivine, etc. The augite is mostly in yellowish and brownish elongated crystals, containing magnetite inclusions. The biotite is in brown irregular scales, while considerable calcite and a greenish fibrous spherulitic product were seen (delessite?). The general structure of the rock is very similar to many nephelite basalts, but no trace of feldspar was seen nor anything that could be referred to nephelite. The augite and magnetite alone, of the mineral constituents observed, are regarded as original. All the rest appear to be secondary. The rock effervesces with hydrochloric acid but does not gelatinize, showing that the olivine is entirely altered and that nephelite is not now present. This rock is regarded as an old and altered basalt.

Diabase.

The diabase (881) of Hoskin's Harbor, Thwart Island, occurs in a dike about twenty feet wide, running north and south, and cutting argillite. The rock is a gray finely crystalline abase containing pyrites, and weathering brownish gray. ection greenish gray, and appears to have been originally mposed of divergent feldspar (plagioclase) with the interaces filled by irregular grains and dissected masses of augite, agnetite, olivine (?), etc. At present the augite is in general lly slightly altered, and is of a brownish color or nearly lorless. It is much fissured, sometimes cloudy and at others tered to a greenish chloritic material. The feldspars are, for e most part kaolinized and altered, although retaining disnct evidence of their triclinic character.

Of secondary products there occur, among others, considerale chloritic material, some calcite, quartz, microlites, and ctinolite fibers. A few greenish masses were seen that may e pseudomorphs of olivine granules, their forms and polarization characters being the same as those of such pseudomorphs seen in other basaltic rocks.

At Tom Hall's harbor, on Exploits Burnt Island, the main rock is a diabase cut by numerous later diabase dikes. The former (850) is a grayish green crystalline rock showing feldspar and pyrite crystals. Under the microscope it is seen to be composed of divergent basaltic plagioclase with the interspaces filled by magnetite and secondary viridite, chlorite, and epidote. The feldspars are somewhat altered, although polarizing with brilliant colors, and contain epidote granules, chlorite scales, and colorless needles resembling tremolite. The chlorite is dichroic, varying from a pale yellowish to greenish. The epidote is in granules varying from a yellowish to a colorless state. This rock was found to be more or less jointed and fissured, and where it was more broken than usual segregations f copper and iron pyrites existed. These limited and worthess masses had been taken as evidence of extensive deposits f chalcopyrite and considerable money expended in prospectg, etc.

A short distance from this locality at Green Island Cove, me prospecting had been done in a similar diabase rock conining some copper and iron pyrites. In the section the neral structure of this (853) rock is seen to be the same as at of the preceding (850) but it has suffered further alteran so that the feldspars are considerably changed. Some lcite occurs in the rock.

This rock is also cut by diabase dikes, one of which (851) is greenish gray finely crystalline rock but more compact than e preceding and somewhat fresher. In the section it is seen be only a little less altered than No. 853. Considerable lcite and some greenish secondary hornblende was observed, herwise the two sections are nearly the same.

Another diabase occurring near No. 850, and perhaps a portion of the same mass, is more coarsely crystalline with pinkish feldspars. At the western point enclosing Sargent's Cove, a coarse-grained basaltic rock (867) occurs cut by fine-grained diabase dikes (866).

The rock on the north side of Betts Cove is a diabase, which on the weathered surfaces shows spherulitic concretions of impure epidotic material. These concretions are seen to be a superficial phenomenon, for they diminish in size and amount in the interior.

No. 903 from Little Bay Mine, is a greenish rock flecked by pinkish spots of alteration origin. Under the microscope the greenish section is seen to be from a rock entirely altered, a natural condition when it is realized that the dike from which it came forms the line about which is arranged the ore of the mine. The section is composed of an irregular confused granular aggregation of secondary epidote, chlorite, green and white mica, quartz, feldspar, microlites, etc. The epidote and chloritic and micaceous material predominate. This rock is similar to some specimens in the collection from Sonora, Tuolumne County, California.

Diorite.

At Sargent's Cove a coarse grained old basaltic rock, No. 867, occurs. This is of a dark greenish color and composed macroscopically chiefly of black hornblendic crystals. The section is composed of a confused mass of secondary greenish and brownish fibers and crystals of hornblende, magnetite, talc-like masses, carbonates, pseudomorphs apparently after olivine, which seem to be mainly dolomitic, mica, etc. From many observations that the writer has made on rocks of like character he is led to regard all these coarse dioritic rocks as formed from the alteration both of gabbros and coarse-grained diabases.

Porodite.

On the mainland at Needle Cove, Exploits Bay, the rock is a coarse (877, 878) and fine (879, 880) fragmental rock of dark greenish, gray color, and composed of eruptive detritus—probably a volcanic ash. It contains pyrite and calcite. The specimens are composed principally of melaphyr material with the secondary products: chlorite, some colorless pyroxene, quartz, etc. Magnetite and decomposed feldspar occur. Much of the melaphyr was evidently a cellular, glassy basalt and in some cases is still black and opaque. If it were not that the cells are filled with secondary materials it would be difficult sometimes to distinguish these melaphyr grains from some of the rtiary basalts of California. In most of the fragments the e basaltic feldspars retain their forms.

These rocks belong to the old tufaceous products to which I ave given the name of porodite,* but since the basaltic mate- al predominates in them they are placed under that species.

ANDESITE (?)

Minette, or Mica Trap.

At Great Lobster Cove a "mica trap" was found, running orth 40° east, and thirty-two inches in width. No. 855 came rom the edge of this dike and is a dark, brownish gray rock, weathering rusty brown and containing crystals and plates of black mica and hornblende needles, with some pyrite and quartz. The brownish gray section is composed of a yellowish and grayish white groundmass holding augite, hornblende, magnetite, and biotite crystals. The rock is much altered, but the augite is indigenous, and in relatively large porphyritically inclosed crystals, having a well-marked cleavage. The central portion of the larger augite is of the usual pale yellowish color, but the exterior is of a pale pinkish-brown tint, observed so commonly in the European augites. Connected with this alteration of color is seen in some crystals an immense number of straight hair-like microlites. The color and the microlites both appear to be associated with the alteration. The augite is both in short, thick forms, and in elongated crystals and microlites, and has more the character of the augite of the andesites than that of the basalts. The maller crystals and microlites are usually of the pale pinkish-rown color.

The hornblende is in both short and elongated crystals, with a ichroism varying from light yellowish brown to dark brown. t is almost identical in general appearance with the mica, but optically different, while the cleavage of the hornblende is early wanting. Both minerals are abundant. The ground- ass is composed of a pale yellowish or grayish mass, mostly otropic, but sometimes polarizing feebly; and containing merous microlites, granules, etc. It also holds calcite and eenish fibrous spherulitic delessite (?), which sometimes forms ncretionary masses with centers of calcite.

No. 856 came also from the edge of the dike, but is more ecomposed. The section is essentially the same as the preced- g, but there are more fibrous products of decomposition and ore calcite. The augite is less in amount and the crystals ometimes have a greenish dichroic center. Owing to the reater alteration, the groundmass here shows generally some olarization.

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* l. c. p. 280.

No. 857, from the central portion of the dike contains well-developed biotite and augite crystals, with calcite and quartz grains. Some of the biotite crystals inclose portions of the rock mass in the center. The section is composed of a dense groundmass of augite, biotite and hornblende microlites with calcite, magnetite, and some grayish white binding material generally isotropic. The augites sometimes have greenish centers with yellowish external portions. One form, composed of veins of viriditic material inclosing dolomite, resembled an olivine pseudomorph. Considerable greenish fibrous spherulitic material, like delessite, occurs associated with calcite.

No. 858 is from the center of the dike and is essentially the same as the preceding.

Of the ingredients of this dike, the augite and magnetite alone of the minerals observed are regarded as original materials, all the rest are considered to be secondary or alteration products.

No. 855 effervesces strongly with hydrochloric acid, but does not gelatinize.

The difficult question with this mica trap is, what was the original state of the rock. The characters now remaining indicate that it was once a basalt or an andesite, its present condition being due to alteration since its eruption. The structure of the porphyritic augites, with their relation to the groundmass, indicate an altered andesite, while in many respects the rock resembles the melaphyr, No. 865, previously described. The preponderance of its original characters appears to be of an andesite type, and it is with doubt classed under that species.

In a similar manner from their structure and pseudomorphs, the minette (5015) from Himmelsfürst, near Freiberg in Saxony, and that from Weinheim in Baden (5080) appear to be altered and old andesites.

Porphyrite.

A brownish gray rock from Wells's Cove, Exploits Bay, cuts the argillite and is composed of a brownish gray granular groundmass with greenish spots, and segregations of calcite. In the section it is seen to be composed of altered plagioclase and orthoclase, with ferrite, quartz, calcite and chlorite forming a groundmass which incloses larger, altered porphyritic feldspar crystals. The plagioclastic forms appear to have predominated, although the alteration is so great the decision is doubtful. In the present condition the mass is chiefly composed of secondary ferrite granules, quartz, calcite and chlorite, with microlites, etc. It is difficult to say to what species—basalt, andesite, or trachyte—this rock belonged, but it most closely resembles the andesites.

ARGILLITE.

The western part of Exploits Burnt Island shows an indurated argillite (864), and jasper (862), associated with a fine-grained conglomerate or coarse sandstone (863). The latter is seen, under the microscope, to be composed of fragments of feldspar, quartz, magnetite, melaphyr, etc., cemented by a matrix. In the hand specimen, jaspery and argillite fragments were observed. The matrix is now altered mainly to a chloritic mass containing a few quartz grains, feldspars, etc. The chloritic material is mostly isotropic and in some places shows a structure that might readily be taken for a fluidal one. This seems to be owing to the crystallization of the chloritic scales in vein-like deposits. The feldspathic fragments form the chief portion of the section and are much altered now, showing aggregate polarization, and having a fibrous kaolinized and talc-like structure. The quartz is in irregular fissured grains containing stone and fluid cavities bearing moving bubbles. The melaphyr is much altered, retaining only its structure. While this rock is composed mostly of ordinary detritus it may in part be from volcanic ashes.

An argillite (868) coming from the southwest part of the island is greatly indurated, breaks with a conchoidal fracture, and is composed of a grayish green groundmass holding quartz grains. Under the microscope this is seen to be a distinctly clastic rock like the preceding, and while in the main fine-grained it contained some larger fragments like No. 863.

It is now composed of greenish micaceous scales, quartz, feldspar, ferrite, microlites, etc. The quartz and feldspar (orthoclase) are both a fragmental and a secondary production, probably through water action. A few broken crystals resembling zircons were seen.

At Easter Cove, Exploits Bay (on the main land, near Muddy Hole), the argillite is much indurated, although less so than the preceding. The strata here show a varying dip from 30° to 90° (usually 60° to 80°) to the southward. The strata are much contorted and bent, and in one place a general northward dip was seen. A section of the argillite No. 869 closely resembles No. 868, being of similar character, but finer grained and of lighter color. It is traversed by veins of quartz and calcite. Near Welles' Cove, Exploits Bay, the argillite is black, laminated like a shale, and cut by dikes of diabase and porphyrite.

On the west side of Lawrence Harbor the shaly argillite stands nearly vertical and carries graptolites.

Jasper.

Where the lava flows or intrusive masses come in contact with the argillite the latter is often baked to a dark brick-red jaspery mass, irregularly fissured, traversed by minute quartz and calcite veins and breaking with a conchoidal fracture. One section (862) is composed of a reddish brown groundmass of ferrite globules mingled with secondary quartz and holding numerous globular and irregular patches of quartz. These segregations oftentimes form the principal portion of the section. Veins filled with quartz and calcite with some epidote traverse the section. Some chlorite, microlite, margarites, trichites and fluid inclusions occur in the quartz veins. No. 859 is a denser rock and contains more epidote, both in the veins and in rounded segregations. These jasper rocks have been quite extensively acted upon apparently by thermal waters, and were found to pass into distinguishable argillites at a short distance from the point of contact with the eruptive rocks. Both specimens were found to be infusible* before the blowpipe, although little fused globules appeared in the case of No. 859, owing to the epidote in it. Observations made by myself indicate that rocks ordinarily called jasper are formed by the induration of argillite by eruptive action, by chemical deposition, and by eruption—the second form only being true jasper.

THE ORE DEPOSITS.

At the time of my visit the lower levels of the Betts Cove Mine were filled with water. The mining had been done in an irregular manner, taking the ore wherever it could be found; thus the walls not having sufficient support had broken away on one side and fallen in. All the work then doing was in the taking out of ground that had been left in the upper workings.

The mine is in mixed argillite, chlorite schist, and diabase. The ore band runs east and west, and is cut by north and south dikes, of which there were said to be ten in the mine. The dikes seen were all diabase. Over one-half of the adjacent country rock is eruptive, but all the ore of importance is found in the schistose portions formed from the altered argillite and diabase. The ore is of secondary deposition, being a segregation in the broken fissured altered portions of the rock, and, judging from the ore seen and the workings, must have occurred in immense irregular masses The ore is chalcopyrite mixed with pyrite, quartz, etc. The foot wall is formed by diabase.

The upper portion of Little Bay Mine is worked in chlorite schist impregnated with chalcopyrite. The whole is longitudily cut by a dike (No. 903) parallel with which run three ds of chalcopyrite which lie near the dike. In depth these ee bands pass into one, varying from six inches to four feet thickness, and the mixed chlorite schist and ore of the er portion of the mine is wanting. The character of the rkings and the geological structure seen in this mine show t this deposit was an immense lenticular mass of schist pregnated with impure chalcopyrite, the widest portion ng on the surface and gradually narrowing in depth. The from this locality is mixed chalcopyrite and pyrite with artz, schist, etc.

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* Fusibility of the Amorphous Varieties of Quartz. Proc. Bost. Soc. Nat. Hist., 1877, xix, 238.

The Roberts Arm Mine is worked on two veins from two to r feet wide in the eruptive diabase. The veins are comsed of quartz carrying very compact chalcopyrite. While e veins widen in depth they do not appear to improve in antity or quality of the ore. The sides of the veins are distinct and firmly attached to the country rock, thus partakg more the character of a gash than a fissure vein. The same nd of veinstone and ore has been sunk upon at a locality own as "Sandy Vein" about one-fourth of a mile distant.

At Lawrence Harbor the old basaltic lava had been proscted for ore and considerable work done, but the vein is nply a gash vein containing quartz carrying pyrite. A vein the shaly argillite had been worked to some extent, but owed only some impure graphite with quartz.

At Hoskins Harbor, Thwart Island, Exploits Bay, a grayish ack, somewhat indurated, nearly vertical argillite (882), is cut a north and south dike of diabase (881), about twenty feet width. This diabase is cut by a few gash veins of pyrite, artz, and calcite containing a little chalcopyrite and malachite. hese veins had been worked to some extent by persons not quainted with their limited occurrence. The mode of occurnce of the copper ores in northern Newfoundland, taken with e geological structure of the country, indicates the following their origin. The argillaceous and schistose rocks have en cut through and through by dikes and irregular masses of uptive basaltic rocks. During the time of this eruptive tivity, after the chief portion of this basalt had been travasated, the action of percolating thermal waters on the uptive rock and its fissured and broken adjoining sedimentary ck, led to the concentration and deposition of the copper, n, and quartz in the places in which they are found.* The pper is here thought to have been brought up from below ely disseminated through the basaltic material and later ncentrated by the percolating waters.

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*See Bull. Mus. Comp. Zool., 1880, vii, 123–131; Proc. Bost. Soc. Nat. Hist., 30, xxi, 91–103.

The productive masses of ore seen were found in connection with these old basaltic masses, but generally deposited in the adjacent schist or in decomposed portions of the diabase, for the boundary lines of the eruptive masses afforded the conditions necessary for the precipitation of the copper sulphide. The eruptive masses are as a rule too massive and compact to afford suitable places for the deposition of the ores, thus the prospector is naturally to search for them in the schists adjacent to the large eruptive masses. The deposits thus occurring are irregular segregations or impregnations of varying bulk, but they do not promise in any one locality long continued mining. It is perhaps best to do as seems to have been done up to the time of my visit; work the mines in an irregular slovenly manner, stripping out the ore masses wherever found, so far as safety permits, with the idea of abandoning the mines as soon as the chief portion of the ore is extracted. The Betts Cove and Little Bay Mines at the time of my visit presented to me the appearance of having been well worked out, although considerable ore yet remained, particularly in the latter.

One prevalent error regarding the rocks of this country ought to be corrected, i. e. the belief that the ores are associated with serpentine. No serpentine was seen by me at any of the points touched between Twillingate and Betts Cove except one small bowlder at the latter place. I am informed it exists in that vicinity, and Mr. Murray assured me it occurs at Tilt Cove. The ores, so far as seen, occurred in diabase and schists; hence the statements, so industriously circulated in almost every article relating to the Newfoundland copper deposits, regarding the relation of the ores to serpentine are entirely incorrect in the districts seen by me.

In closing, I desire to express my warm thanks to the veteran director of the Geological Survey of Newfoundland, Alexander Murray, C.M.G., for his many kind favors during my stay in St. John's, and my regrets that ill health has compelled him to resign the post he has so long held.

Cambridge, Mass., March 22d, 1884.

Art. XV.—*The Origin of Bitumens;* by S. F. Peckham, A.M.*

Speculation regarding the origin of bitumens has been pursued during the last half century along several quite different lines of investigation, and has been influenced by several different classes of experience. Generally speaking, these lines fall into three different classes and embrace those who regard bitumen as a product of chemical action, those who regard it as indigenous to the rocks in which it is found, and those who regard bitumen as a distillate produced by natural causes.

The argument for a purely chemical origin of petroleum was first brought to the serious attention of scientific men by Berthelot in 1866. He found that when carbonic acid or the earthy carbonates were brought to react with alkali metals at a high temperature, oily fluids were formed similar to or identical with those found in petroleum. Byasson produced the same fluids by causing steam, carbonic acid and iron to react; and Cloez produced them by the reaction of boiling water upon a carbide of manganese. The chemists of this school assume that the alkali metals, iron at a white heat and spiegeleisen with other raw chemical reagents, exist in the interior of the earth, and that petroleum is formed by the reaction upon them of carbonic acid in water which everywhere infiltrates the terrestrial crust. These chemical theories are supported by great names, and are based upon very elaborate researches, but they require the assumption of operations nowhere witnessed in nature or known to technology.

M. Coquand, who has written so fully upon the occurrence of bitumen in Albania and Roumania, and C. H. Hitchcock, have both advocated the theory that all forms of bitumen are produced by a chemical reaction in which marsh gas is converted into more condensed hydro-carbons, appearing as fluid, viscous and solid bitumens. In so far as this theory expresses the fact that maltha represents an intermediate stage in the transformation of petroleum into asphaltum and recognizes the relation existing between marsh gas and the petroleum compounds, it is entitled to consideration; but in the chemical processes of nature, complex organic compounds pass to simpler forms, of which operation, marsh gas, like asphaltum, is a resultant and never the crude material upon which decomposing forces act.

The opinion that petroleum is indigenous to the rocks in which it is found has been maintained with great vigor by T. Sterry Hunt and J. P. Lesley, both of whom have based their views upon extended observations in Canada, West Virginia and Kentucky. At several localities in Canada, Dr. Hunt has observed the marine fossils of the Trenton limestone filled with petroleum in which it was hermetically sealed, and he regards the petroleum that saturates portions of the Niagara limestone near Chicago, as indigenous to that formation. In a recent letter, J. M. Safford informs me that in the limestone rocks that form the Silurian basin of middle Tennessee it is not uncommon to meet with geode cavities lined with calcite crystals and containing more or less petroleum. I am also informed by Edward Orton that the Clinton limestone of Ohio, lying over the whole northern border of the Cincinnati anticlinal, contains petroleum in small quantities. In J. P. Lesley's paper on "the existence of petroleum in the eastern coal field of Kentucky," he has shown that in Johnson County, Kentucky, the great Carboniferous conglomerate is saturated with petroleum at horizons now above the level of the water in the streams that intersect the country. He thinks the Coal-measure plants contributed to the formation of the petroleum and observes that "the specific gravities of the oil, decreasing with the increase of the depth, is a fact which shows conclusively that a chronic evaporation or distillation of the whole mass of oil in the crust of the earth (within reasonable reach of the surface), has always been and is still going on, converting the animal and plant remains into light oils, the light oils into heavy oils, the heavy oils into asphalt or albertite, the process being accompanied at every stage with the liberation of gas." In his introduction to Report III, of the Second Geological Survey of Pennsylvania, he remarks "that it (petroleum) is in some way connected with the vastly abundant accumulations of Paleozoic sea-weeds, the marks of which are so infinitely numerous in the rocks, and with the infinitude of corralloid sea animals, the skeletons of which make up a large part of the limestone formations which lie several thousand feet beneath the Venango oil-sand group, scarcely admits of dispute, but the exact process of its manufacture, of its transfer, and of its storage in the gravel beds, is utterly unknown." It is evident that in these later statements Professor Lesley expresses his opinion respecting the changes that convert the original petroleum content of the rocks into the different varieties of petroleum now met with, although in his earlier papers and particularly in the one first quoted, Lesley has been one of the most conspicuous advocates of the opinion that the petroleum of the Appalachian system is indigenous to the rocks in which it is found. The observations of Wall in Trinidad appear to establish beyond a doubt that the bitumen of that locality has been and is being produced om a peculiar decomposition of woody fibre. Bright and restwich both regard the petroleum of England as indigeous in the limestones and shales, and the testimony of E. W. inney is conclusive as to the production of petroleum from he decomposition of peat on Down Holland moss. J. D. Vhitney has suggested that the infusorial remains so abundant n the sedimentary rocks of Southern California, are the orig-nal source of the petroleum occurring in them.*

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* Abstract of Chapter V of the Monograph on Petroleum, prepared for the Tenth Census of the United States.

I think no doubt can be entertained that in certain localities f limited extent petroleum and other forms of bitumen are indigenous to the rocks in which they occur.

As early as 1804 Humboldt observed a petroleum spring issuing from metamorphic rocks in the bay of Cumana and expressed the opinion that it was "the effect of distillation at an immense depth." . . . . Dr. J. S. Newberry and the late Professor E. B. Andrews have both called attention to the similar character of the distillates obtained from bituminous coals and shales and petroleum and suggested that petroleum is a product of distillation by natural processes and at low temperatures. Daubrée has in "Études sur le Métamorphisme" very fully discussed the relation of bituminous substances to metamorphism and has proved by experiment the adequacy of such an origin for all forms of bitumen.

The studies which I have made upon petroleum, extending now over a period of more than twenty years, lead me to the conclusion that as yet very little is known regarding the chemical geology of petroleum. No one has studied the chemical properties of different varieties of petroleum in relation to their geological occurrence in any effective manner; it would therefore be extremely rash for any one to dogmatize with reference to the origin of bitumens. I am, however, led to state the conclusions that a careful survey of our available knowledge of the subject has enabled me to reach. I am convinced that all bitumens have, in their present condition, originally been derived from animal or vegetable remains, but that the manner of their derivation has not been uniform. I should, therefore, exclude all chemical theories as impossible or unnecessary. There remains the hypothesis that bitumen is indigenous in the rocks in which it is found and that which regards all bitumens as distillates. Whichever of these hypotheses be chosen, the modifying fact must be accepted that there are four kinds of bitumen:

1st. Those bitumens that form asphaltum and do not contain paraffine.

2d. Those bitumens that do not form asphaltum and contain paraffine.

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*Dr. J. S. Newberry has lately erroneously attributed this theory to myself. Ann. N. Y. Acad. Sci., ii, No. 9.

3d. Those bitumens that form asphaltum and contain paraffine.

4th. Solid bitumens that were originally solid when cold or at ordinary temperatures.

The first class includes the bitumens of California and Texas. They are doubtless indigenous in the shales from which they issue. It is also probable that some of the bitumens of Asia belong to this class.

I have described the conditions under which bitumens occur on the Pacific coast of southern California in great detail in the reports that I have made to the Geological Survey of that State. The forms of bitumen that are found there are almost infinite in gradation, from fluid petroleum to solid asphaltum. In Ventura county the petroleum is primarily held in strata of shale, from which it issues as petroleum or maltha, according as the shales have been brought into contact with the atmosphere. The asphaltum is produced by further exposure after the bitumen has reached the surface. These shales are interstratified with sandstones of enormous thickness, but I nowhere observed the petroleum saturating them, although it sometimes escaped from crevices in the sandstone, nor was the bitumen held in crevices of large size nor under a high pressure of gas; the disturbed and broken condition of the strata, folded at high angles, precluding such a possibility.

The topography and stratigraphy of the coast ranges of Santa Barbara, Ventura and Los Angeles counties are very complex. The Santa Barbara islands, off the coast bordering these counties, are volcanic islands, where lava-flows are described as having formed cascades over cliffs of sedimentary rocks as they descended into the sea. On the mainland no lava appears to have reached the surface, although along the stage road from San Buena Ventura to Los Angeles, between Las Posas and Simi, on an eroded plateau surrounded by low mountains, fragments of scoria are scattered over the ground. The Coast Ranges here appear to have been produced by parallel folds, each successively higher, by which enormously thick beds of sandstone, interstratified with shale, were thrust up at an angle of about 70°, producing parallel anticlinals, which were subsequently eroded in such a manner as in many instances to produce valleys and plateaus where the sandstones were broken through to the softer shales beneath. This is the case with the western extremity of that fold which, commencing at Point Conception, extends eastward to Mount San Bernardino. West of the Sespé the sandstone crest has been completely removed and the shales cut away until, at the Rincon, east of Santa Barbara, the erosion reaches the sea-level, and beyond, to the westward, the upturned edges of the shale orm the bed of the ocean. The narrow plain on which Santa Barbara stands, lying between the Santa Iñez mountains and the sea, consists of Pliocene and Quaternary sands and gravels resting upon the eroded shales. East of the Rincon and Mount Hoar, the table-lands lying in the trough of the anticlinal gradually ascend until at the Sespé the sandstone caps the high mountain to the eastward. This range, occasionally broken by transverse cañons, extends to near the headwaters of the Santa Clara River near the Solidad Pass, where it becomes merged in the San Rafael range. Between Point Conception and Point Rincon, where a stratum of sand occurs saturated with maltha, that substance has arisen and floated on the sea, attracting the notice of travelers ever since that coast was known to Europeans. At Point Rincon, where the anticlinal recedes from the coast, maltha rises and saturates the Quaternary sands. As the ascending plateau passes farther inland we find a line of outcrop of the bituminous strata on the east and west sides of the basin in the line of hills east of Mount Hoar and in the Santa Iñez mountains. East of the San Buena Ventura River, the local synclinal fold in the shale forming the Azufre mountain gives four lines of bituminous outcrop. In the cañons of the Sespé, wherever the bituminous strata have been reached by erosion, tar springs and asphalt beds are the result. The deeply-eroded narrow valleys which cover the country east of Santa Barbara and south of the Coast Range present in the distance of a few miles the greatest lithological variations, and expose the bituminous strata under the greatest diversity of conditions. For this reason we meet here every possible form of bitumen in every possible degree of admixture, with soil and organic remains.

The second class of bitumens includes the petroleums of New York, Pennsylvania, Ohio and West Virginia. These oils are undoubtedly distillates from vegetable remains, the proof of which seems overwhelming. Pennsylvania petroleum was examined in 1865 by Warren and Storer in this country, and in 1863 by Pelouze and Cahours in France. They found the lighter portion to consist of certain series of hydrocarbons identical with those obtained in the destructive distillation of coal, bituminous shales and wood when the operation was conducted at low temperatures. Messrs. Warren and Storer also discovered that the same series of hydrocarbons could be obtained by distilling a lime soap prepared from fish oil. The experience of technology has shown that if coals or pyroschists are distilled at the lowest possible temperature, particularly in the presence of steam, a black, tarry distillate is obtained along with a considerable quantity of marsh gas, and very volatile liquids that cannot be condensed except at low temperatures.

If these distillates are re-distilled, the second distillate may be divided into several different materials, beginning with marsh-gas and ending with very dense oils heavily charged with paraffine. It is impossible to conduct this primary or secondary distillation without producing marsh-gas, but the amount of this gas and the density of the fluid produced will depend on the temperature at which the distillation is carried on and the rapidity of the process. The use of superheated steam is found to increase the quantity of distillate and to prevent overheating, and the formation of other hydrocarbons than those belonging to the paraffine series.

The section compiled by Mr. J. F. Carll, for Report III of the Reports of the Second Geological Survey of Pennsylvania, shows the Devonian shales above the Corniferous limestone and below the Bradford third oil-sand 1600 feet in thickness. This shale outcrops along lake Erie, between Buffalo, New York, and Cleveland, Ohio, where it is for the most part the surface rock in the neighborhood of Erie and southward to Union City, Pennsylvania. No one can examine this shale without noticing the immense quantity of fucoidal remains that it contains. N. S. Shaler estimates the Devonian black shale of Kentucky to cover 18,000 square miles at an average depth of 100 feet, and to yield on distillation fifteen per cent of fluid distillate. It is not necessary to follow him in his calculations of the enormous bulk of this distillate as represented in barrels; the important point in this connection, is that it is a very persistent formation, being revealed by borings over a very wide area, and doubtless extending eastward beyond the boundaries of Kentucky, beneath the coal-measures which contain the petroleum.

If, however, the Devonian black shales are inadequate both on account of extent and position as a source of supply, we may descend still lower in the geological series to the Nashville limestone and other Silurian rocks that underlie that region. Professor Safford writes, in a recent letter, "The Lower Silurian limestone in the basin of middle Tennessee is about 1000 feet thick. Including the Upper Silurian limestones, the whole thickness of the limestones, in which are found occasionally little pockets or geodes and cavities of petroleum, is not far from 1200 feet. The most of the petroleum has been found in the upper part (the Nashville) of the Lower Silurian, as, for example, the larger cavities near or on the upper Cumberland River, in the neighborhood of the Kentucky line, both within Kentucky and Tennessee." These limestones underlie the whole petroleum region of southeastern Kentucky and middle Tennessee.

The objection urged by Professor Andrews, that the coals in measures of Ohio and West Virginia, among which these ıls occur, have lost nothing of their volatile content, is witht force here. Professor Shaler objects that—"The condition the beds that lie below the black shale in the Cincinnati oup or in the Niagara section shows that there has been no eat invasion of heat since the beds were deposited. Clays, nich change greatly under a heat of 1000° Fahr., are apparıtly exactly as they were left by the sea, and beds retain ieir marine salts just as when they were deposited. Any reat access of temperature in this deposit of the Ohio shale ould have been attended by an almost equal rise of temperaure in the coal-beds which lie within a few hundred feet bove; but these coal-beds are free from any evidences of disillation or consequences of heat. We have already seen easons for supposing an erosion of some 3000 or 4000 feet of trata from this section; if we could reimpose this section we hould probably bring up the temperature of these rocks by he rise of the isogeothermals or lines of equal temperature ıbout 60°. . . . We are not able to suppose that the accumuation of strata would have elevated the temperature above he boiling point of water. The hypothesis which may be ound to account for the formation of this coal-oil must take nto consideration the impossibility of its generation at another oint and its removal to this set of beds, and the impossibility f supposing that it has been in any way the result of high emperatures."

The range of temperature between "the boiling-point of vater" and "1000° Fahr.," which is here allowed, is ample for ll purposes of explanation.

Mendeljeff objects that—"the sandstones impregnated with etroleum, have never exhibited the carbonized remains of rganisms. In general, petroleum and carbon are never found imultaneously."

These three objections—first, that the supply of organic natter is inadequate; second, that there are no evidences of ıeat action upon the rocks holding the oil; third, that there re no residues of fixed carbon observed in the rocks holding he oil—are the objections which have appeared to satisfy hose who do not accept the hypothesis that regards petroleum s a distillate. I think the first has been already answered; he second and third I shall now examine.

It is not the effects of heat, as represented by volcanic ction, that have produced petroleum, although in one notable nstance Silvestri found paraffine and other constituents of etroleum in the lava of Etna. A comparison of the analyses f the gaseous emanations of volcanoes with those of gas and etroleum springs shows that the former consist mainly of carbonic acid and nitrogen, while the latter consist mainly of marsh-gas. Bitumens are not the product of the high temperatures and violent action of volcanoes, but of the slow and gentle changes at low temperatures due to metamorphic action upon strata buried at immense depths.

The extent of the Paleozoic formations of the Mississippi valley, and the general conformation of the bottom of the ancient seas, has been fully described by Professor James Hall.* He says: "In all the lower Silurian limestones we trace the outcrop to the west and northwest, from the base of the Appalachians in New York or in Canada, to the Mississippi River, and thence still in the same northwesterly direction. . . . Instead of finding the lower Helderberg (Upper Silurian), strata in lines parallel with those of the preceding rocks, the relative direction of the main accumulation and the principal line of exposures is diagonally across the others. . . . The line of outcrop and of accumulation has been from northeast to southwest, and they occur in great force far to the northeast in Gaspé, on the Gulf of St. Lawrence. . . . The greatest accumulation of materials in the period of the Hamilton, Portage and Chemung groups (Lower and Middle Devonian), lies in the direction of the Appalachian chain. . . . In Gaspé there are 7000 feet of strata, . . . while in western New York the whole together would not exceed 3000 feet. We have, therefore, the clearest evidence that the strata thin out in a westerly direction. . . . In considering the distribution of the masses of the formations which we have here described, we find that the greatest accumulations have been along the direction of the Appalachian chain. The material thus transported would be distributed precisely as in an ocean traversed by a current like our present Gulf Stream; and in the gradual motion of the waters during that period, to the west and southwest, the finer material would be spread out in gradually diminished quantities, till finally the deposit from that source must cease altogether. . . . I have long since shown that . . . the portion of the Appalachians known as the Green Mountain range is composed of altered sediments of Silurian age. . . . The evidences in regard to the White Mountains, to a great extent are of newer age than those of the Green Mountains, or Devonian and Carboniferous. . . . The statements of Sir William Logan in regard to the great accumulation of strata in the peninsula of Gaspé, together with the observations of Professor Rogers in the Appalachians of Pennsylvania, lead to the inevitable conclusion that the sediments of this age must everywhere contribute largely to the matter forming the metamorphic portion of the Appalachian chain as well as to the non-metamorphic zone immediately on the west of it."

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* Nat. Hist. N. Y. Paleontology, iii. 45–60.

.t is not necessary here to discuss the nature or origin of tamorphic action. It is sufficient for our purpose to know it from the Upper Silurian to the close of the Carboniferous iod the currents of the primeval ocean were transporting liments from northeast to southwest, sorting them into ivel, sand and clay, forming gravel bars and great sand beds neath the ripples, and clay banks in still waters, burying st accumulations of sea weeds and sea animals far beneath the rface. The alteration due to the combined action of heat, eam and pressure, that involved the formations of the Appachian system, from Point Gaspé in Canada, to Lookout .ountain, in Tennessee, including the Carboniferous and earer strata, distorting and folding them, converting the coal ito anthracite and the clays into crystalline schists, along ieir eastern border, could not have ceased to act westward long an arbitrary line, but must have gradually died out urther and farther from the surface. The great beds of shale nd limestone containing fucoids, animal remains and even inigenous petroleum, must have been invaded by this heat ction to a greater or less degree, and that "chronic evaporaion" of Professor Lesley must have been the inevitable conseuence.

Too little is known about petroleum at this time to enable ny one to explain all the phenomena attending the occurrence f petroleum, upon any hypothesis; but it seems to me that the ifferent varieties of petroleum, from Franklin dark oil near he surface, to Bradford and Clarendon amber oil far beneath he surface, are the products of fractional distillation; and one f the strongest proofs of this hypothesis is found in the large ontent of paraffine in the Bradford oil under the enormous ressure to which it is subjected. So, too, the great pools of il in southern Kentucky are without doubt distilled from the eode cavities beneath and concentrated in fissures of the ocks near the surface.

If this hypothesis, which embraces all of the facts that have hus far come within my knowledge, really represents the perations of nature, then we must seek the evidences of heat ction at a depth far below the unaltered rocks in which the etroleum is now stored. We ought to expect to find the coal n its normal condition. We should not expect to find the arbonized remains of organisms in the rocks containing the etroleum. As the metamorphic action took place subsequent o the Carboniferous era, we should expect to find the porous andstones of that formation in certain localities saturated with etroleum. Moreover, we should expect to find these Coal-neasure sandstones and conglomerates on the western border f the heated area, where the thinning out of the deposits

brought down the Coal-measures nearer the Devonian sl
and Silurian limestones, first saturated with petroleum,
then, through ages of repose, gradually cut down by ero
into the cañons of Johnson county, Kentucky, and exhibi
all of the phenomena described by Professor Lesley.

The inadequacy of the scattered remains of plants in
Coal-measure sandstones as a source of the petroleum that s
rates them is shown by the following calculation, which
made by Professor Lesley for another purpose: "Should
Mississippi send down one tree a minute for a century, witl
average length of forty feet and a foot in diameter, and tl
be laid together side by side at the bottom of the sea in a
gle stratum, they would cover only a space of 200 ac
Were it possible, which it is not, to compress and crysta
these lignites into a stratum six feet thick, they might t
constitute a coal bed covering twenty acres. All the forest
the Mississippi valley could not furnish to the sea from t
river spoils during a hundred thousand years one of the antl
cite coal beds of Schuylkill county."*

According to M. Coquand, the petroleum of Wallachia i
the inferior Tertiary with mud volcanoes and rock salt;
"Flysch à Fucoids" is the horizon in Moldavia, correspond
to the formation in which it occurs in the Crimea, Transylva
Galicia, Volterra of Tuscany, the Appennines, Sicily,
Algeria, being everywhere rich in fucoids. The conclusi
reached by geologists regarding the occurrence of petrol
in Galicia show that the central core of the Carpathians c
sists of metamorphic rocks, on the flanks of which lie
members of the Cretaceous and Tertiary formations, consis
of limestones, sandstones and shales. The latter are for
most part rich in organic matter both vegetable and ani
such as fossil fucoids and fish. In East Galicia and Bukov
heavy beds of black bituminous shales are particularly not
able. These formations lie in folds, the petroleum, which
longs to the third class, occurring under the arches of anticli
rather than in the troughs of synclinals.

The facts to be obtained regarding the occurrence of bitu
in Asia are very few. It appears to be generally conclu
that the formation from which the petroleum in the neigh
hood of the Caucasus arises is Tertiary; but so far as I
ascertain it issues rather from erratic beds of sand in superfi
clays than from any well-defined formation. Lartet appea
regard the bitumen of the Dead Sea as of volcanic origin. '
petroleum of Java lies in the Tertiary beneath alluvium, wl
flanks the volcanic core of the island.

Granting that the petroleum of the Niagara limestone

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* A Manual of Coal and its Topography, p. 49.

Chicago is indigenous, the invasion of that limestone by steam under high pressure would cause the petroleum to accumulate in any rock lying above, porous or fissured sufficiently to receive it. The mingling of oils that produce asphaltum and those that contain paraffine, and the occurrence of paraffine in large masses in porous strata filled with the remains of fucoids and marine animals that flank the core of crystalline schists in Roumania and Galicia, offers the strongest support to this hypothesis. The fact that the eruptive rocks of Lake Superior and the metamorphic rocks farther east prevail to such an extent that that vast inland sea has been supposed to be the crater of an extinct volcanic lake lends the strongest support to an hypothesis that regards the vast accumulations of petroleum in Western Canada as due to invasion of strata on the borders of this heat center, in which the petroleum is indigenous, by a sufficiently elevated temperature to cause its distillation.

Mud volcanoes and hot springs, it appears to me, are properly regarded as the phenomena attending the gradual subsidence of metamorphic action in the crust of a cooling earth. The accompanying petroleum or maltha is but the accident of such phenomena when strata containing organic remains are still invaded at a great depth by a temperature sufficiently elevated to effect the distillation of their organic contents. Gas springs may own the same origin, or the gas may escape from deep-seated reservoirs, the product of a distillation long since completed.

Solid bitumens of the fourth class occur in great variety.

The universal distribution of bituminous material in rocks was noticed in 1823 by the Hon. Geo. Knox. The occurrence of disseminated bitumen in metamorphic rocks, supposed to be Laurentian, at Nullaberg, in West Sweden, has been described; also in the lower Silurian of south Scotland; in trap near New Haven, Connecticut; and in northern New Jersey, all of which are manifestly the results of the action of heat upon the organic matter in stratified rocks. The occurrence of bituminous limestones in France and in the valley of the Rhone has been attributed almost unanimously by French geologists to the action of igneous or metamorphic agencies.

There remain the phenomena attending the occurrence of large veins of solid bitumen in Cuba, West Virginia, New Brunswick and elsewhere, for which no adequate explanation has been proposed that does not regard them as the product of distillation from deep-seated strata, which has been projected into a fissure formed by the sudden rupture of the earth's crust. Dr. R. C. Taylor examined the vein which occurs in metamorphic rocks near Havana, and concluded that, "it was evidently originally an irregular open fissure, terminating upward in a wedge-like form, having various branches, all of which have been subsequently filled with carbonaceous matter, as if injected from below, and that not by slow degrees, but suddenly and at once." No hint is given by Dr. Taylor respecting the age of these rocks, as at the time he wrote (1837) the relation between metamorphic and sedimentary rocks had not been established. There is little doubt, however, that the veins in New Brunswick and in West Virginia originated at nearly the same time and subsequently to the Carboniferous era. It is certain that subsequent to that era a great convulsion caused an upheaval that in collapse produced the White Oak anticlinal in West Virginia, very near the southern end of which occurs the vein of Grahamite, cutting the horizontal sandstones of the Coal-measures vertically. Those who mined the vein declare that the material must have welled up from beneath into the fissure the instant it was formed. Numerous fragments of the wall-rock were found imbedded in the asphaltum twelve to fifteen feet below the cavities from which they fell, with all of their edges and angles sharp and exactly fitting each other. Curious curved lines, resembling those produced when a stone is dropped into mortar, are found on these horses, suggesting the probability that the horses fell into a plastic mass that rolled upon them, producing lines of unequal pressure and adhesion that remain after the asphaltum has cleaved from the horses or enclosing walls. Moreover, neither the walls of porous sandstone, nor the horses, have absorbed the bitumen to the thickness of paper. The significance of these facts was more forcibly impressed upon my mind when I found among a suite of specimens from the Albertite vein of New Brunswick a piece of the inclosing shale, marked with the mineral in forms almost identical with those observed on the sandstone horses in West Virginia.*

In 1869 I made the origin of albertite and allied substances the subject of a paper in which I compared the observations made in New Brunswick and West Virginia with my own observations of a vein on the coast of California, which is exposed west of Santa Barbara, and stands vertical, cutting the Pliocene and recent sands. With this vein are associated lenticular masses extending horizontally, from which a sort of talus projects vertically into the sands beneath.† Similar deposits are described by M. Coquand as occurring in Albania. He mentions in connection with the bituminous strata, solfataras and mud volcanoes both active and extinct, with which was associated more or less fluid maltha, which was at first very liquid, but soon became syrupy and was finally added to the accumulations of the bituminous cone. From his statement it appears that solid bitumen occurs in great abundance, filling variously formed cavities which in no case penetrates the roof above the mass, "but was evidently injected from below." Here the maltha accompanies the water of springs from deep-seated strata often in close proximity to active or extinct volcanic action of the mild forms observed as solfataras, mud volcanoes or salses. The great similarity in the occurrence of intruded Tertiary bitumens in Albania and California is very remarkable.

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* Very carefully drawn illustrations of these stones have been introduced in the original monograph.

† This Journal, II, xlviii, 362.

It should be borne in mind that while this subject is one of speculation, pure and simple, it is a subject that has its valuable consideration outside the domain of scientific enquiry or curiosity, as affecting the sources and duration of supplies of petroleum, its profitable development and commercial permanence. If petroleum is the product of a purely chemical process, we should not expect to find Paleozoic petroleums of a composition corresponding with the simple animal and vegetable organisms that flourished at that period, and Tertiary petroleums containing nitrogen, unstable and corresponding with the decomposition products of more highly organized beings; but we should expect to find a general uniformity in the character of the substance, wherever found, all over the earth.. The advocates of the chemical theory affirm that they provide for a process the conditions of which are perpetually renewed. It is thus continuous and at present active. On the contrary, if petroleum is the product of metamorphism, its generation is coexistent only with that of metamorphic action, an action which we have no reason to believe has been prevalent on a large scale during the recent period. If we accept this hypothesis, the generation of petroleum must be considered as practically ended.

ART. XVI.—*On the Measurement of rapidly alternating Electric Currents with the Galvanometer;** by L. M. CHEESMAN.

Preliminary.—In view of the frequent use made of rapidly alternating electric currents in determining the resistance of liquids, etc., a more delicate instrument than the one we now have for such determinations has become a desideratum. At Professor von Helmholtz's instigation I endeavored some time ago to employ the deflections arising from electromagnetic action for this purpose. The following pages give a brief account of the experiments made in this direction.

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* From a paper by L. M. Cheesman, read before the Royal Academy of Sciences of Prussia by Professor von Helmholtz, July 13, 1882.

After a number of experiments on the action of alternating currents on soft iron, with rather unsatisfactory results, a phenomenon first carefully studied by Poggendorff* was chosen as a basis for further study. The phenomenon referred to can be described as follows: if rapidly alternating electric currents are passed through the coil of an ordinary galvanometer, placed so that the plane of the windings makes an angle with the magnetic meridian, a deflection takes place in such a direction as to still further increase the angle between the plane of windings and the needle; in other words, the needle strives to take up a position at right angles to the plane of the windings. Poggendorff explained this by referring the phenomenon to the action of the alternating currents on the temporary magnetism induced by them in the needle of the galvanometer, the resultant action of the currents on the permanent magnetism of the needle being zero.

To examine this explanation more closely, suppose rapidly alternating currents, each of equal intensity, to be sent through the coil of a galvanometer placed so that the needle makes an angle of about 45° with the plane of the windings. The magnetic effect of the coil on the needle can be divided into two components, one parallel to the magnetic axis of the needle, producing no rotation but tending to magnetize it positively or negatively according to the direction of the current passing at the moment; a second at right angles to the magnetic axis tending to produce rotation in the needle. The effect of two consecutive currents on the needle, the first positive and the second negative, would evidently be as follows; the first with the intensity $(+i)$ increases the magnetic moment (M) already present in the needle by some quantity (m), so that there exists a moment of rotation proportional to $i(M+m)$; similarly the second current with the intensity $(-i)$ decreases the magnetic moment (M) of the needle by the same quantity (m), so that the moment of rotation in this case is proportional to $-i(M-m)$. The moment of rotation therefore arising from the two consecutive currents is proportional to $i(M+m)-i(M-m)=2im$, independent therefore of the permanent magnetism of the needle. By a similar course of reasoning it will be readily seen that the moment of rotation due to the horizontal intensity (T) of the earth's magnetism tending to draw the needle back into the meridian is independent of the induced magnetic moments and proportional to 2TM.

Preliminary experiments to ascertain whether the phenomenon above described could be employed for the desired purpose were made with an ordinary galvanometer placed so that the plane of the windings made an angle of about 45°

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* Pogg. Ann., xlv, 1838.

ith the magnetic meridian; the alternating currents were tained from a small induction apparatus of the du Bois-aymond form. The following points were to be considered: st, whether the apparatus was sufficiently sensitive, and cond, whether for the same intensity of current the needle ways had a determined position, which it would not have d did the currents employed in any way alter the permanent agnetism of the needle. The results of the experiments in oth of the above particulars were sufficiently favorable to arrant the hope that after a few changes a practical instrument based on the above principle could be made.

Description of Apparatus.—The following is the form of the nstrument finally adopted. The circular coils and metal parts onnected with the damper of a galvanometer of Edelmann's orm were removed and in their stead were placed two coils, ach having 2200 turns of silk-covered copper wire (diameter ·25^{mm}). The play-room for the magnet was a right-angled arallelopipedon, 11^{mm} in height, 61^{mm} in breadth and length; he resistance of the two coils together amounted to 474 ohms. The magnet consisted of eleven hard steel wires (diameter 1·6^{mm}) securely fastened together and magnetized to saturation by a large number of impulses of the magnetizing force. As the deflection of the needle, other things remaining the same, is greater as the product of its permanent magnetic moment and the horizontal intensity of the earth's magnetism is less, the sensitiveness can be heightened by diminishing the value of this product. In this instrument, as noticed above, the moment of rotation from the currents being independent of the permanent magnetic moment, the reduction of either the permanent moment or the horizontal intensity would have the result of increasing the delicacy. Should the permanent magnetic moment be reduced by using unsaturated magnets there would be danger that the magnetic condition of the needle would not remain constant when acted upon by the alternating currents; the same result can, however, evidently be attained without this disadvantage by fastening saturated magnets together, some of them having their poles reversed; the usual method of diminishing the value of the horizontal intensity by approaching permanent magnets is, however, to be preferred.

Magnetization of the Needle.—In regard to the galvanometer needle it is to be noticed that the trustworthiness of the results obtained with the above instrument depends on its not being altered, except temporarily, by the action of the alternating currents. The effect of a magnetizing force on a magnet is, however, in general both of a temporary and a permanent character; were induction in magnets always accompanied by this permanent change, the construction of a trustworthy instrument based on the above principles would evidently be impossible. Fromme* has shown that this is not always the case, and from his experiments he draws the following conclusions: first, that when steel is magnetized by a large number of impulses of the magnetizing force the magnetic moment approaches a fixed limit for every intensity of the magnetizing force as the number of impulses increases; second, that after the limiting magnetic moment for a force P has been reached, forces between 0 and P are incapable of effecting any permanent change in the magnetism of the steel, and the temporary magnetic moment induced by such forces is proportional to the intensity of the force acting.

These laws would seem to require a more special investigation than has yet been made regarding several particulars before their unqualified acceptance; that however the currents did not cause any sensible permanent alteration in the magnetism of the needle employed in my experiments the following experiments I think conclusively show. A permanent change in the magnetic condition of the needle might consist either in a change in the direction of the magnetic axis or a change in the permanent magnetic moment. Had the former occurred by the action of the currents it would evidently have shown itself by irregularities in the position of rest of the needle after the current had been acting; a graphic representation of the positions of rest of the needle in a series of experiments extending over the greater part of a day, the current being closed from time to time, showed, however, no such irregularities. Had the second possibility occurred, that is, had the permanent magnetic moment of the needle been altered by the action of the currents, it would evidently have caused a change in the delicacy of the instrument; this point was carefully tested by repeated comparisons of the delicacy of the instrument with that of a Weber's electro-dynamometer in the same circuit, the results were such as to give no ground for assuming that the delicacy of the instrument underwent any perceptible alteration.

Law of Deflection.—According to the article of Fromme, already cited, the induced magnetism in a magnet which has been magnetized by a large number of impulses of the magnetizing force, increases proportionally with the force, for all forces between zero and P. As mentioned above, some further investigation is required in regard to this point before its application to the case before us, and I hope to make this the subject of a future communication. Assuming, however, that the proportionality exists, the square of the intensity (i) of the currents will be for small deflections approximately proportional to the tangent of the angle of deflection (φ), when the s of the windings of the galvanometer makes an angle of with the magnetic meridian. For suppose the instrument ed so that the axis of the windings makes an angle (α) with magnetic meridian and that the needle has experienced a ection φ from the meridian by the alternating currents; conditions of equilibrium will evidently be,

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* Pogg. Ann. Ergänzungsband, vii, 1876.

$$MT\ \sin\varphi = iM'f(R)\ \sin(\alpha-\varphi),$$

M denoting the permanent magnetic moment,
M' the induced magnetic moment,
T the horizontal intensity of the earth's magnetism,
the intensity of the alternating currents, and
R) a function depending on the number and form of the windings, etc.

M' can be replaced by $if(R)\cos(\alpha-\varphi)$, whence we obtain,

$$i^2 = c\,\frac{\sin\varphi}{\sin 2(\alpha-\varphi)},\quad c = 2.\frac{MT}{[f(R)]^2}.$$

For the special case $\alpha=45°$, $\frac{\sin\varphi}{\sin 2(\alpha-\varphi)}$ differs but 0·2 per it from tan φ, when $\varphi=3°$.

Delicacy.—The following table gives an idea of the delicacy the above instrument and its variation with the time of ration of the needle as altered by reducing the value of the rizontal intensity of the earth's magnetism. The first column gives the time of vibration of the needle, the second the otient obtained by dividing the deflection observed on the lvanometer by that of a Weber's* electro-dynamometer in same circuit, so that the same intensity of current acted in ch case, both deflections of course being reduced to the same le distance. The time of vibration of the dynamometer ool was 20 sec.

Time of vibration.	Quotient of the deflections.
8·3″	0·7
10·	1·1
16·	2·6
22·	4·3

So that for equal times of vibration the galvanometer had nsiderably greater delicacy, although the Weber instrument d over 1800 more turns of wire than the galvanometer.

In conclusion, I should state that a number of determinans of resistances by the method of substitution with alterting currents were made with the above instrument with ry satisfactory results.

Instrument made by Leyser. Number of windings of the stationary spool, 0; resistance, 152 ohms; number of windings of the movable spool, 4380; stance, 205 ohms.

ART. XVII.—*On some Specimens of Nickel Ore from Nevada;* by SPENCER B. NEWBERRY.

WITHIN the past year have appeared frequent references to the occurrence of nickel ores in Churchill Co., Nevada, all seeming to indicate that a very valuable source of supply of nickel has come to light. Through the kindness of Chas. Bell, Esq., of Sacramento, one of the discoverers of the deposit, I was able to obtain a complete series of specimens from the different levels so far opened, namely, the 10 ft., 45 ft., and 60 ft. level, and the 80 ft. drift. The specimens amount in all to about 30 pounds in weight, and are by far the finest masses of nickel ore I have ever seen.

The sample from the greatest depth (80 ft.), consists of nearly pure *niccolite*, which in the 60 ft. and 45 ft. specimens show the progress of oxidation and hydration, this action appearing more complete as the surface is approached. The specimen from the 10 ft. level (nearly eight pounds in weight), consists entirely of the hydrated arseniate, or *annabergite*, with but a small amount of impurity. The analysis of a sample of the entire mass gave:

NiO	33·71	per cent.
As_2O_5	36·44	"
H_2O	24·77	"

The remaining five per cent represents small quantities of iron, copper, and insoluble residue, with traces of cobalt.

In his letter accompanying the specimens, Mr. Bell gives the following description of the deposit:

"The property is situated in Cottonwood Campus, Churchill Co., Nevada. The ledge is perfectly incased, running 6,000 ft. N.E. and S.W., when it pitches into the Carson Desert and is lost. The ledge is thirty feet between walls, the mineral lying in veins, of which there are thirteen in all, each from ten to thirty-five inches wide. The gangue which separates these veins of ore is in layers from four to eight inches wide, and consists of silica, iron, lime and magnesia. The same character of minerals extends throughout the whole length of the lead."

In view of the extraordinary purity and richness of the ore, there can be little doubt that if future developments should bear out the present indications outlined in Mr. Bell's description, the mines of Nevada will eventually become a very prominent source of the world's supply of this valuable metal.

Laboratory of Cornell University, June 30, 1884.

. XVIII.—*Gorges and Waterfalls;* by WILLIAM MORRIS DAVIS.

RROW gorges and abrupt waterfalls are seldom found in ountries of flat rocks and moderate elevation. For a gorge s wider and wider in the course of its natural growth, and nes a broad valley in its maturity and old age; a waterfall ases in height as it is worn farther and farther back, until t it remains only as a faint ripple in the almost uniform -grade of its stream. Kentucky, Ohio, Western Penn- nia and New York are old land surfaces of this kind, and valleys are broadly open, unless bordered by excess- hard rocks, and waterfalls seldom break the even descent eir watercourses, except where the great glacial accident ehistoric times has disturbed their flow. But within the ated area, a stream may, even in the middle part of its e, suddenly enter a narrow gorge, a true cañon in minia- and leap down precipitous falls, while its fellows in the neighborhood and in the same set of rocks have the usual valley slopes of regular descent. Not unfrequently these es are in rocks of very moderate hardness.

will probably be discovered, when all our falls and ravines tudied, that by far the greater number of them result from ocal displacement of streams from their old open channels lockades of glacial drift, or less commonly by temporary uction from the glacial sheet itself. This important gen- zation has often been alluded to in geological reports, as be shown below, but it as yet finds no place in our text- s, although glacial drift is as frequently an essential factor e production of our gorges and falls as in the making of akes and ponds.

is of course to be understood that falls and gorges are pro- d in other ways also. The greatest gorge of the world, the rado Cañon, was formed by rapid downward erosion fol- g the rapid elevation of the plateau in which it is cut; n such a case, all the streams of the region flow in cañons ore or less pronounced form, and the cleft-like appearance e valley is not exceptional. Waterfalls are also found in tries quite free from glacial action; but such countries are rally high, and the cascade, although old, is not yet old gh to have worn its hard bench-rock back into a th, gentle slope. The headwater streams that leap down avines in the massive mountains of southeastern Kentucky examples of this kind. Falls are also sometimes, but very m, produced by faults; the cascades of the Yosemite are plausibly of this kind, and some of the falls in Norway must have the same origin, if Professor Kjerulf's theory of th making of the fjords by dislocation prove correct. But al these examples are in regions quite unlike those of the moderate relief and inconsiderable dislocation that are here to b considered.

The following examples will serve to illustrate the importance of the connection between drift and gorges.

Professor James Hall called attention many years ago to the numerous gorges of western New York.* They are nowhere better shown than along the course of the Genesee. Above Portage there is a broad, alluvial valley, the bottom of an old lake; thence to Mt. Morris the stream flows through a meandering gorge over three hundred feet deep, leaping down several falls, shut in by steep, rocky banks free from drift. Not far to one side, the abandoned preglacial channel may be traced by the heavy drift deposits, which when sounded by wells or borings are found to have a very significant thickness. Lateral streams enter the new channel in deep gorges; or, if small, plunge into it in cascades, giving excellent sections of the upper Devonian strata. Nearly every stream flowing from the south over rocks of this age in western New York presents the same features in a greater or less degree. A hundred examples can be cited where there is demonstrative proof of the recent origin of the gorges. Farther north, from Mt. Morris to Rochester the Genesee again follows an ancient open valley, wandering over alluvial meadows and seldom touching rocky strata; but from Rochester to Lake Ontario it follows a second gorge, the upper end of which is well seen from the trains of the New York Central Railroad as they cross the bridge just above the falls. The abandoned valley is probably a little farther east.

The gorge of the Niagara River is the largest single piece of post-glacial erosion this side of the Mississippi. Just how much of the gorge has been cut since the final disappearance of the ice-sheet cannot now be said with certainty; but it can hardly be questioned that the greater part of this deep channel is of comparatively recent origin, and that it had its beginning when the former open drainage of the valley of Lake Erie was held back, probably by drift obstruction, so as to form the lake and force its overflow to choose a new line of escape; and to this accident we owe our great waterfall.† The numerous glens and ravines down which rapid streams flow into the north and

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* Geology of New York. IV District. 1843, 371, 422. Here and beyond, extracts are sometimes given almost word for word from the authors named, but quotation marks are omitted.

† The evidence for this origin of Lake Erie and Niagara is summarized in my paper on the Classification of Lake Basins. Bost. Soc. Nat. Hist. Proc., xxi, 1882, 362. A recent paper by G. F. Wright on "The Niagara Gorge as a Chronometer," is in the Bibliotheca Sacra, April. 1884.—See also p. 32 of this volume.

th lakes of the western arm of New York must frequently
always have a similar origin; notably the gorge below
ghannock Falls on the west side of Cayuga lake, and Wat-
s Glen at the head of Seneca lake. Trenton Falls and
sable Chasm, farther east, most likely come under the same
ss, but so far as the author knows there are no descriptions
them sufficiently detailed to make the matter sure. Local
dies of these interesting spots would lead to valuable results.
e creek that joins the Mohawk at Canajoharie flows from an
en, flat, drift-covered country into a deep, narrow, rocky
rge. Schoharie Creek has throughout the greater part of its
urse opened a terraced valley in the drift-filling of its old
annel; but a few miles below Gilboa it abruptly enters and
suddenly leaves a rocky chasm, a few hundred yards long
d fifty or more feet deep. Here it has evidently lost its
rmer line of flow, and cut its new bed in the rocky slope of
s old trough. Rondout Creek does the same about two miles
ove its junction with the Hudson.

Several of Professor Newberry's writings* call attention to
e old buried channels in Ohio and the numerous gorges
sulting from turning old streams into new courses. Rocky
iver, for example, which enters Lake Erie seven miles west of
leveland, follows an open valley strewn with drift in the
pper part of its course, but when two miles above its mouth
enters a narrow trough with rocky walls and floor and fol-
ws it to the lake.† A little west of its present point of dis-
harge its ancient channel is seen, now filled with clay to an
nknown depth below the present surface of the lake. Grand
iver, in Lake county, is of similar character.‡ At the falls
ear Akron, the Cuyahoga follows a narrow gorge and in two
iles descends two hundred and twenty feet in a series of cas-
ades. In the same neighborhood there is plentiful drift and
umerous small lakes among the gravel hills. Many lakelets
ave been filled with peat, but nearly one hundred still remain
ithin twenty miles of Akron. From the falls to Cleveland,
here the Cuyahoga enters Lake Erie, the stream follows the
eneral line of its old course, but flows on heavy drift clays
hich bury the rocky bottom of the channel two hundred feet
eep.§ The rapids at the Sault Ste. Marie in the outlet of
ake Superior, and of the Ohio at Louisville, are thought by
rofessor Newberry to mark new channels.

A few miles west of Chillicothe, in central Ohio, there is a
mall stream called Paint creek, which flows for the greater
art of its course through an open, fruitful valley enclosed by

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* Proceedings Bost. Soc. Nat. Hist., ix, 1862-63, 42; Annals N. Y. Lyceum Nat. Hist., ix, 1870, 1; Amer. Naturalist, iv, 1870-71, 193; Geology of Ohio, i, 1872, 42, ii, 1874, 12.

† Geol. Ohio, i, 174.

‡ Id., i, 511.

§ Id., i, 201, etc.

hills of moderate slope about five hundred feet high on eith side. Suddenly and without apparent cause the stream tur from this broad trough and enters a narrow gorge with ste rocky walls not less than three hundred feet high, in which continues for about five miles on a circuitous course, until regains the broad valley three miles below its point of departur The abruptness of the change from the old to the new cours and the striking difference between the gentle, drift-covere and cultivated slopes of the former and the bare, precipito walls and rocky bed of the latter make this case an excelle example for our consideration. There must have been som strong obstacle placed in the old matured channel to cause th creek to leave a course so well suited to its wants; to turn fro what it had been patiently at work preparing for unnumbere thousands of years, and cut out a new passage through the hills and Professor Orton, who first, some ten years ago, gave detailed description of this notable locality,* concludes that th obstacle was the ice of the glacial sheet that had its margi during its farthest southern advance, in this district. Th upper waters of the creek must have been held back by the ic aided by the drift, and risen behind them into a lake, who level is marked by heavy terraces of stratified drift, until a lin of overflow was found around the barrier; and along this ove flow the gorge has been cut out. From the report of the sam geologist on Clarke County,† we learn that its rocky flo beneath the drift, wherever disclosed by streams, railroad cut quarries, or borings, is extremely irregular, showing the exist ence of an old buried drainage system, the minor features o which have been almost obliterated by the drift deposits tha deeply cover nearly all the surface and greatly reduce its relie The old channels were choked with sand and clay brough there by the ice and water of the Glacial period; and whe those strange conditions ended and the modern or postglacia period began, the waters, gathering again from the rain an springs, had to make new choice of channels. The lines of th old streams were selected in the greatest number of cases, fo though their rocky troughs were buried deep out of sight, th drift mantle was still as a rule lower there than on the adjoining hills. But sometimes the streams found their best escap along new lines of flow: there they have abandoned the ol channels and wrought out new ones, and these constitute mos of the narrow gorges in the cliff rock that make so notable feature in the scenery of this region.

The Falls of St. Anthony in the Mississippi at Minneapoli and the gorge below them are shown by Professor N. H. Wi chell* to result from a displacement of the river from its older and wider channel that ran west of the present course from a point just above Minneapolis, down to the wide channel of the Minnesota River, three miles above Fort Snelling. The Mississippi, forced by an ice or a drift blockade to depart from its old channel, rose till it reached the level of the limestone bluffs of its eastern bank; a lake was thus formed from which abundant deposits of fine brick-clay remain. The overflow ran across country about eight miles to Fort Snelling, where the old channel was again taken; in plunging over the limestone bluffs, the waters gave birth to the Falls of St. Anthony. Since that time, the falls have receded to their present position, leaving a narrow valley below them; and from the records of early exploration Professor Winchell has computed that this recession of eight miles has occupied somewhat less than nine thousand years. The Falls of Minnehaha are in a side ravine branching from this new channel of the Mississippi a little over a mile above the original site of the Falls of St. Anthony at Fort Snelling. Their ravine was therefore begun about a thousand years later than the Mississippi channel, and being the work of a much smaller stream, their recession is only about one mile from the front of the new Mississippi bluffs. Several still smaller falls along the bluffs have the same origin. The dalles of the St. Croix and the rapids of St. Louis rivers, also in Minnesota, may probably be referred to postglacial erosion, but explicit statements of their origin are not to be found. The southern peninsula of Michigan must also furnish many examples of newly made falls and gorges, for the streams there are described as generally flowing on the drift, but sometimes cutting down into the rock.

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* Geological Survey of Ohio ii. 1874. 653.

† Geol. Ohio. i. 489.

Professor I. C. White, of the Geological Survey of Pennsylvania, has given several excellent descriptions of gorges. Wallenpaupack Creek, dividing Wayne and Pike counties in the northeastern part of the State, is one of the most striking examples of its class. In preglacial times, it had carved out a wide and deep channel in Catskill strata from the Pocono plateau northeastward to its junction with the Lackawaxen, having a descent of four hundred feet in eleven miles without any notable falls so far as can be discovered. During the Glacial period, the lower end of the channel was filled with drift to a depth of three hundred feet, so that, where the ice melted away, the re-established drainage found a shorter cut and lower passage to the Lackawaxen about three miles above its former mouth. For ten miles above the obstruction, the 'Paupack meanders through a broad, flat, swampy valley, the bottom of a recently extinct lake, with a fall of only half a foot in a mile:

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* Geol. Minn., 4th Ann. Report, 1876, 178.

it then enters a narrow gorge, and in one mile descends t hundred and sixty feet in a succession of cascades and rapi Blooming Grove Creek, a few miles east of the 'Paupack another example of the same kind. Again, Shohola Creek tributary of the Delaware, once entered that river about hal mile below its present mouth through a channel now deej buried; the creek has cut down a new passage through t rocky cliffs bordering the river, thus making the great goı at Shohola Glen since the close of the Glacial period. The fa of the Raymondskill and the Sawkill, near the angle of Pei sylvania between New York and New Jersey, are both due new courses around obstructions in drift-filled valleys. T Delaware, where these streams join it, flows southwest along t outcrop of the soft Marcellus Shale, bounded on the southe by the back of a ridge held up by the Oriskany sandstone, a on the northwest by the bluffs of the Hamilton group. In lo preglacial time, the streams from the northwest had cut de gaps through the line of bluffs, and had insignificant falls any; now they plunge over the Hamilton cliffs. The eviden of this change is perfectly clear and satisfactory. In the ca of the Sawkill, there is a point back of the bluffs about thr miles from the Delaware, where a narrow ridge of drift, on twenty-five feet higher than the present channel, turns t stream away from a low, deep, drift-filled valley to the ea cut down far lower than the head of the falls; and yet nothi flows along this old valley but a trifling stream fed by a fe springs. The conclusion that it was once the course of t Sawkill is irresistible, for the Sawkill brings all the water fro the back country needed to accomplish the excavation of deep and broad a trough. The drift-filling where the stream turned to its new course toward the falls is estimated to three hundred feet thick. The explanation of the new cour of the Raymondskill is equally conclusive. Professor Whi suggests that the several other high cascades over the Hamilt bluffs along the Delaware in this part of its course, such those on Adam's, Dingman, Hornbeck and Little Bushk Creeks owe their origin to a diversion from their old channe by drift-dams; but no detailed study of their topography w made.*

Other illustrations of our topic described by the same autho are found on the highlands northwest of Wyoming Valle Harvey's lake is a long, narrow, irregularly shaped body water, occupying an old buried valley to a depth of nine feet. The old outlet is closed by drift; the new line of ov flow has already lowered the lake over one hundred feet utting a narrow, gorge-like channel, with bare outcropping ocks free from drift for one hundred and twenty-five feet above he lake level. Crooked Lake, also in Wyoming county but on he other side of the deep valley of the Susquehanna, has the ame origin; the old valley below the lake is now without a tream, for the overflow has turned to one side, first running ith gentle slope over drift deposits; then descending one undred and ten feet in a narrow gorge over a series of rocky ascades. Here it joins Buttermilk Creek, the lower course of which has been entirely changed by glacial deposits. Vast heaps of drift are piled up in the old channel about the mouth of the ancient stream, so that its modern representative is turned aside to plunge over the cliffs of Catskill rocks into the valley of the Susquehanna. In the deep, narrow gorge that has thus been formed, the stream falls eighty feet in several cascades in a horizontal distance of two hundred yards. The old valley can be traced nearly clogged with drift heaps; and the evidence of the change in the stream's course is said to be singularly clear and conclusive.

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* Geol. Penn., G6, Pike and Munroe Counties. 1882, 57–62.

† Geol. Penn., G7, Wyoming. etc. Counties, 1883, 171, 131, 133.

Other post-glacial valleys, with steep rocky walls and very little drift are described by Mr. Carll in western Pennsylvania, while the old valleys are broad and deeply filled with heavy drift deposits.*

The most appreciative description that I have found of the relation between drift obstructions and river gorges is in Mr. J. Geikie's 'Great Ice Age.' Nothing can be more striking—this author writes—than the sudden and complete change of scenery that ensues upon the passage of a stream from its new into its old channel. In the former the water frets and fumes between lofty walls of rock, which, seen from below, appear to rise almost vertically from the river's bed. In such a deep, narrow gorge the stream may continue to flow for miles, when of a sudden the precipitous cliffs abruptly terminate, and the water then escapes into a broad vale, with long sloping banks of stony clay, sand and gravel. The burial of old valleys is especially common in districts where they stretch across the advance of the ice; the gorges of the Avon and the Calder, branches of the Clyde, are thus explained as post-glacial cuts, to one side of the drift-filled, pre-glacial channels.†

Mr. A. Geikie writes of one of the most remarkable gorges in Scotland,‡ that of the Mouse water, in the district of the Cartland crags, near Lanark. The stream descending from the shady ravines of Cleghorn flows smoothly for half a mile through an old valley still choked up with bowlder-clay. This valley runs on below the house of Baronald, but instead of keeping this, which was probably its ancient course, prior to bowlder-clay times, the river turns abruptly round in front of Baronald, and plunges into the old Red Sandstone, through which it has worked a dizzy ravine, some 200 feet or more in depth, whose western precipices are known as the Cartland crags. Emerging from this well-nigh twilight gorge, the river rejoins its old channel and soon loses itself in the Clyde. Some other examples are named.

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* Geol. Penn., III, Oil Regions, 1880, 347.

† Great Ice Age, 1877, 133.

‡ On the Glacial Drift of Scotland, Trans. Geol. Soc. Glasgow, i, pt. 2, 1863, 51.

That this clear description was not generally appreciated is shown in a later account of the same gorge, where although it is recognized as of aqueous origin, wonder is expressed that the downward erosion should have so greatly exceeded the lateral cutting.*

In view of these many examples, it seems fair to regard the falls and gorges of our Northern States as the result of glaciation, and to group them with the rolling surface of the drift, dotted over with ponds and lakes, as signs of an immature drainage system. The long pre-glacial time of land-existence gave our rivers east of the Mississippi ample opportunity to perfect their courses; to destroy all the lakes that must have existed in great numbers while the land was rising and the mountains were growing; to wear back all the falls until they disappeared, or until they retreated to the higher regions of the little headwater streams; and to widen all the valley slopes to a well opened angle, except where especially hard rocks persist in holding the streams within narrow channels. Then came the ice invasion, bringing altogether new conditions over the Northern States; hills and ledges were rounded off and valleys were widened and deepened; the rubbish was strewn over the country in a most irregular way, thin at one place, thicker at another; and although in part carried by subglacial streams, it was chiefly scraped along by the ice itself. Its transportation was under control of forces quite unlike those that prevailed during pre-glacial times, and hence its deposition was largely independent of the glacial stream courses. At the end of the Glacial period, while the streams well south of the ice-limits were still persevering in their perfect ways, those on the glaciated area often found that much of their previous work was lost and had to be done over again. As fast as the ice melted back, the rivers took possession of the country, and while the larger and stronger ones in nearly all cases found escape along their accustomed channels, many of the smaller streams were quite bewildered and lost their way among the heaps and sheets of drift that masked their old valleys, and had to settle down as best they might on the lowest ground they could find.

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* Dougall, Falls of Clyde, Trans. Geol. Soc. Glasgow, iii, 51, 1871.

hey were restrained in lakes and ponds behind drift barriers, d were turned aside from a life of comparative ease in their ell-prepared old channels to an age of hard work in active ck cutting—and here we now see them, just accommodated their new lines of life.

An old stream, having its volume, its load of silt and its ope so related to one another that its channel is eroded with treme slowness, comes as near to a condition of stability as reams can. It has, after a long age of endeavor, at last lapted itself to its environment, and has very little tendency variation. But any change in its condition of life sets it at ork again, seeking another attitude of satisfied equilibrium. , for example, the land across which an elderly, conservative ream flows, is elevated with comparative suddenness, the ream finds its point of discharge lowered, and thereupon sets work, with all the strength gathered from its whole drainage sin, to cut the lower end of its valley down to the level of iet water again; and the deep cutting will work its way ckward up stream, requiring a readjustment to the new ope up to the head of every little creek and rivulet of its asin. For a time, during the change, the deepening of the hannel will go on faster than the widening, and the old flat alley will be marked by a gorge-like trough along its median ne. Thousands of valleys of this compound form may be een in the streams of the Rocky Mountain region. Indeed it as in that region that this important relation of the cutting ower of a stream to its "base-level of erosion" was first well ppreciated; and its illustration includes some of the finest ork of our government geologists. On the other hand, if the and were depressed, the level of dead water would advance bove the former mouth of the stream, and the submerged part f the valley would be slowly buried in delta deposits.

Both of these changes are effected at once by the drift blockdes that glacial action has thrown so plentifully across our northern valleys. Above the obstruction, the stream becomes lake, and is deadened into inactivity. Silt from the headwaters settles here and in time will fill the lake and form a marsh or meadow. On the lower side of the obstruction, the stream finds a strong descent, and there begins the rapid deepening of the channel chosen for escape. If this overflow channel be upon the drift barrier itself, and the down-slope below it be pronounced, then the lake is drained before much thickness of silt accumulates upon its bottom. In this way, many of ur marshy meadows have been formed. If the slope of the utlet be gentle, or if a moderate down-cutting will make it so, hen the lake has a much longer life; and this is the case of the great number of our smaller lakes and ponds that still remain. Finally, if the overflow be turned aside from the old valley way, and find its line of escape leading over steep sloping rocks, the gorges, cascades and waterfalls will mark its line and give character to the new channel. Even in soft, shaly rocks, the down-cutting in such cases is much faster than the lateral widening; and in the relatively early stages of development the gorges will be narrow and steep-walled. We now are in this stage, as is abundantly shown by the examples already quoted. We have to thank the old ice-sheet for our picturesque gorges as well as for our pleasing lakes.

It has been suggested that the gorges are in many cases the work of subglacial streams during the presence of the ice, instead of the effect of open water cutting in later times. To a certain extent this may be true; but when, as so commonly happens, there are clear signs of the former existence of a lake above the gorge, then the work must be considered essentially postglacial. For if the gorge had been cut under the ice, then no lake would accumulate in the valley above it when the ice melted away.

It is to be hoped that detailed observation may be directed to some good examples of these attractive elements of our scenery, and that clearly drawn topographical and geological maps may be prepared to illustrate the peculiarity of their forms. A set of large diagrams, in which views and maps of our gorges might form several members, is greatly needed to aid the teaching of geography by giving far clearer understanding of the typical forms of landscape than is possibly attained from description or from the small figures given in ordinary text-books. Cannot some of those who enjoy appreciative study of local geography during their summer tours aid in the collection of such material? The points of special importance for observation are: the topography and the general geological structure of the region; transverse profiles of the stream above, below and in the gorge; a longitudinal profile of the gorge showing its length, depth and descent; evidence to prove the existence of an obstructed channel between the open parts of the old valley above and below the gorge; effects of the obstruction in forming a lake, marsh or meadow above the gorge, and especially any terraces showing the former stand of a lake above the present level of discharge. Maps, sections and views would greatly improve a verbal description. The small advantage taken of the numerous opportunities for such work as this shows the little success of our geographic teaching.

Cambridge, Mass., June, 1884.

ART. XIX.—*The Influence of Light on the Electrical Resistances of Metals;* by ARTHUR E. BOSTWICK.

THE fact that light has an influence on the electrical resistance of the element selenium has been known since 1832. The discovery was made by Superintendent Mai of the Valentia cable station, and the results of a few experiments on the subject were communicated to the Royal Society by Lieutenant Sale[*] in March of the year above mentioned. Since that time this property of selenium has received further investigation at the hands of Professor W. G. Adams, Dr. W. Siemens and others, and some recent applications of it, more or less practical in their nature, have made it familiar. In connection with the experiments on selenium it has also been established that tellurium possesses the same quality of having its resistance affected by light, though in a much less degree.

The effect of light on these substances is to diminish their resistance. In the case of selenium this diminution has in some instances been found to amount to a large proportion of the entire resistance.[†] Tellurium shows a diminution of less than one per cent, the greatest diminution obtained by Adams being one three-hundredth.[‡]

In the year 1877, Dr. Richard Börnstein of Heidelberg[§] attempted to show that the property which had been established in the case of selenium and tellurium was not peculiar to those substances, but was possessed in common with them by gold, silver, platinum, and probably by all other metals, though in a very much less degree. He announced as the result of his experiments that the effect of light upon gold, silver and platinum was to diminish their resistance by from one and one-half hundredths of one per cent up to four per cent of the whole resistance. Shortly after this, Siemens[‖] and Hansemann[¶] of Berlin undertook and completed an investigation in which they were totally unable to detect any action like that described by Börnstein. The matter rested here until 1881, when Börnstein published[**] an account of a new series of experiments, from the results of which it would appear that the electrical resistance of silver is diminished one and one-fourth hundredths of one per cent by the action of light. As far as the writer knows, nothing more had been published on the subject when he made the series of experiments which are to be described in the present paper.

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[*] Proc. Roy. Soc. Lond., May, 1873.

[†] C. E. Fritts "On a New Form of Selenium Cell;" this Journal, Dec., 1883.

[‡] Proc. Roy. Soc. Lond., June 17, 1876 and Jan. 6, 1876.

[§] Phil. Mag., V, vol. iii, 1877, p. 481.

[‖] Berlin Monatsberichte, June, 1877. [¶] Ibid.

[**] Carl's Repertorium, xvii Bd., 2 und 3 heft, S. 164.

Börnstein's first series of experiments were made upon platinum wires and thin leaves of gold, silver and platinum, mounted on glass. His principal methods were two in number. The first consisted in the comparison of the resistances of two wires or plates by means of a Wheatstone's bridge, the plates being alternately illuminated. The second method consisted in the observation of the logarithmic decrement of the swing of a galvanometer needle, the galvanometer being coupled in a circuit with a single plate which was alternately lighted and darkened. The latter method is the one known as Weber's method of damped vibrations. By these methods Börnstein obtained results, which, although alike qualitatively, differed a great deal in amount. Each set seemed to show that the resistance of the metals examined was diminished by light, but the diminution shown by the first method was only about one one-hundredth of one per cent, while that shown by the second was from three to four per cent. This difference Börnstein accounts for by supposing that the passage of an electric current through a metal diminishes its sensibility to light. The metals would then be more sensitive when traversed only by the extremely feeble currents induced by the swinging needle, than when the comparatively powerful current necessary in the Wheatstone's bridge was passing through them. Börnstein's results seemed to show also that the action of light on the metals experimented upon was greatest when they had been kept in darkness for some time, —a fact which had already been observed in the case of selenium.

The methods used by Siemens and Hansemann differed from both of those employed by Börnstein. These observers made no direct measurements but noted merely the slight changes of position of the index of a very sensitive galvanometer which was coupled either in a Wheatstone's bridge, or in a simple circuit with a source of electricity and the metal plate to be examined, the plate being illuminated and darkened at short intervals In Hansemann's investigation, by means of a chronograph, an exact record of the oscillations of the index was kept and curves drawn to represent them. These curves give no evidence whatever that the movement of the index depended in any way on the illumination of the plates. The circuit was closed for from five to ten minutes at a time, the light being thrown on and off the plates every twenty seconds. The movement of the needle during any period of illumination or non-illumination never exceeded ten scale divisions, and its direction as often indicated an increase as a decrease of resistance. The sensitiveness of the galvanometer was tested at each series observations, and it was found that a scale division corres- nded to a change in the resistance of about five-thousandths one per cent. It will be noticed that the circuit was closed ring the entire time of each set of observations. In view of örnstein's theory that the passage of a current diminishes the nsitiveness of a metal to light, Hansemann used as source of ectricity an iron-copper thermo-element having an electro- otive force of less than ·001 volt, and producing a current mparable with those induced by the swinging needle in the amping method. Hansemann also tried a series of experi- ents by the damping method and found no diminution of esistance. The change, however, which he could have detected y this method was not much under one per cent.

Börnstein's second series of observations were entirely upon ilver, deposited chemically on glass, and consisted of direct neasurements of the ratio of the resistances of two plates by means of a Wheatstone's bridge, with sliding contact wire. He exposed his plates to the light for periods of fifteen minutes each. The mean of his results shows a diminution of one and one-quarter hundredths of one per cent, which he attributes to the action of light.

The experiments of Siemens and Hansemann seem to Börnstein to prove nothing concerning the influence in general of light upon the resistance of metals. For in them the plates were constantly traversed by a current, and moreover the illumination was for exceedingly short intervals. As regards the first condition, we know nothing of the influence of the electric current upon thin sheets of metal, and this influence should therefore be as much as possible done away with in searching for a delicate effect, and in the second place the light effect, if there is one, may take considerable time and the exposures should therefore be reasonably long. Börnstein therefore ascribes the fact that he obtains a different result from Siemens and Hansemann to his long exposures and to the fact that the current passed through his plates only during the short time occupied in making the measurements.

The further discussion of these points is left until after the description of the experiments made by the writer.

These experiments were made in the Yale College Laboratory in a room from which light could be entirely excluded. The walls and furniture were painted black. The plates of metal used were five in number and will be distinguished by the letters A, B, C, D and E. A and B were of silver deposited on plate glass by the method given in Browning's pamphlet "A Plea for Reflectors." They were thin enough to transmit about fifty per cent of light and were three and one-half inches long by two broad. These plates were mounted on a slab of wood having two holes two and one-half inches square cut in it. Over these holes the plates were laid, the edges resting for three-eighths of an inch upon rolls of silver foil, through which the connections were made. Two strips of wood were screwed down over the edges of the plates to fasten them, and both sides of the slab were then covered with black paper, holes being cut in it slightly smaller than the plates. The plates, thus mounted, were held in a common clamp-stand. These plates were afterward shaved down to strips one-eighth of an inch wide. In this state they will be referred to as A′ and B′. C, D and E were plates of platinum, gold and silver respectively, deposited on glass in vacuo by Professor A. W. Wright some years ago. They were all thin enough to transmit light easily and measured one and one-half by one inches. These plates were mounted in a small black wooden box having a hole the size of the plate on either side, to admit the light. The plates rested on strips of platinum foil, through which the connections were made, and against which they were firmly pressed by hinged flaps of wood, which could be screwed down as tightly as desired.

The resistances of the plates and connections were as follows:

A	5·5	ohms.	Connections	·087	ohms.
B	12·	"	"	·083	"
A′	74·56	"	"	·087	"
B′	126·72	"	"	·083	"
C	9·33	"	"	·045	"
D	6·25	"	"	·045	"
E	10·27	"	"	·045	"

Galvanometer.—A Thomson's reflecting galvanometer of 7096 ohms resistance was used. Its two coils were connected in multiple arc, making the resistance 1774 ohms. The slit was adjusted so that the spot of light was about two millimeters in width, and the position of the right hand edge was read with the assistance of a small magnifying glass. The feeble light necessary for reading the scale was obtained, sometimes by reflecting the vertical rays of the galvanometer lamp from a sheet of white paper: sometimes by admitting a little light through a shutter. Generally, however, as it was necessary only to record the movement of the index over a few scale divisions, the light from the spot itself, owing to its size, enabled its position to be easily read off. The scale used was a straight one. A resistance box made by Elliot was employed by means of which 12320 ohms could be introduced into the circuit by pulling out plugs. It was arranged on the decimal system.

Rheostat.—A sliding rheostat was used, having two parallel platinum wires which could be connected in series or multiple rc. Each wire was one meter in length and had a resistance f two ohms. The slide was worked by a long handle so that ie observer was never near the rheostat wire except for the ew seconds occupied in reading the scale. The latter was irectly beneath the wires and was graduated to millimeters. it the end of the handle a micrometer screw was so arranged hat the slide could be moved an exact number of millimeters. he rheostat was connected to the resistance box by a wire of 289 ohm resistance, which was taken into account in making ll measurements. The rheostat wire was protected from the lirect radiations of the galvanometer lamp by a wooden screen ind no trouble from this source was experienced.

Battery.—A single Daniell cell of from ten to sixteen ohms resistance was used. Very rarely two cells were used, coupled in series. A key which could be used as a commutator, or simply as a make and break circuit, was introduced in the battery circuit.

Source of Light.—This was a common argand gas burner, surrounded by a copper jacket having in its side a small circular opening. The rays from this opening were brought to a focus by means of a lens, at some little distance from the plate, so that the spot of light thrown upon the latter was about one and one-half inches in diameter. A screen, under the control of the observer, served to cut off the rays from the plate where it was desired. A cubical glass cell with a side of three and one-half inches and filled with a saturated solution of alum, was used in nearly all the experiments to cut off the obscure radiations of the lamp from the plate. In one series, sunlight was used, a beam from a heliostat placed in an adjoining room, being admitted through a hole in the wall. The spot of light on the plate was of the same dimensions as before.

On account of the increase of temperature in the room it was found necessary during part of the series of experiments to place the plates in a separate apartment, the light being admitted to them through a hole in the wall.

Methods.—It is impossible to say *à priori*, whether an effect of light on the electrical resistance of a metal, if there were any such effect, would be instantaneous or gradual. If the effect were an apparent one, due to some direct action of the radiation upon the current passing through the metal, the former would probably be the case, but if the light effected some change in the molecular structure of the metal, it would doubtless take place somewhat gradually. However this may be, it was thought best to divide the experiments into two classes; first, those to discover whether there were an instantaneous effect of light, and second, those to discover the effect of exposures for periods of from ten to fifteen minutes.

Method I.—The plate was connected as one arm of a Wheatstone's bridge. Two of the other arms were made up of resistance coils, and remained constant; the fourth could be varied by pulling out plugs from the resistance box and by means of the rheostat, whose wires were connected in series. The resistance of the plate was measured in the ordinary way to the tenth of an ohm by the resistance box, and further decimal places were obtained by the rheostat, care being taken to determine the length of double wire having a resistance of one ohm at each observation. This was found not to vary at any time more than a few millimeters from 265.

The resistance of the connections was determined at the close of the series by substituting for the plate a sheet of silvered copper of negligable resistance.

The sensibility, or number of scale divisions traversed by the index for the introduction into the circuit of one millimeter of rheostat wire, was also determined for each set of observations in the following manner. The micrometer screw at the end of the rheostat slide was so adjusted as to allow the slide a movement of just one millimeter. Ten readings of the index were then taken, the slide being alternately at its extreme positions. The mean of the differences between every two successive readings was taken as the deflection sought. By this method the effect of a steady movement of the index in one direction during the determination of the sensibility was eliminated. As the stream lines in the plate can be regarded as approximately parallel, the ratio of the resistance of the illuminated portion to that of the whole plate is sensibly that of their areas.

The percentage of change of resistance in the lighted portion of the plate corresponding to a movement of the galvanometer index one scale division evidently

$$= \frac{100}{r\,.\,s\,.\,n\,.\,\mathrm{R}\,.\,a},$$

where "r" is the ratio of the constant arms of the bridge, "s" the sensibility for one millimeter, "n" the length of rheostat wire having a resistance of one ohm, "R" the resistance of the plate, and "a" the fraction of the plate covered by the light spot. It is assumed that the observer could detect a movement of the index amounting to one-fourth of a scale division.

The method, then, was as follows: The plate resistance and sensibility having been determined, the index was balanced and the circuit closed. When the spot was perfectly still, the light was suddenly thrown on the plate and the movement of the index, if any, was noted. The spot had generally a steady ent toward the left corresponding to the increased resist- the plate caused by the heating effect of the current, avoid waiting for the moments when it was at rest the ng method was also used. The movement of the spot ee periods of ten seconds each was recorded, the plate lighted during the middle period, and the difference n the second reading and the mean of the first and third ten as the effect produced by the light. Plates A and illuminated both with gas and sunlight,—C, D and E s light only.

illumination with sunlight took place directly after the f observations described under method II, and the con- s were therefore left as in that method. The formula r calculating the percentage of change of resistance cor- ling to a galvanometer deflection of one scale division o be found there.

od II.—Plates A and B were connected as two arms of lge. The other two arms each consisted of part of the ce box and part of the rheostat, the wires of the latter onnected in multiple arc. Moving the slide therefore ed the resistance in one arm and diminished that of the The length of wire having a resistance of one ohm was etermined. The index was balanced, one ohm taken he box and the index again balanced. Calling the by which the rheostat slide was pushed up M, and gth of wire having a resistance of one ohm n, 10 and 25 espectively being the resistances in the box,

$$25:10::24+\frac{M}{n}:10-\frac{M}{n} \text{ approximately.}$$

his n was found in terms of M, and was found equal to . As the plates were lighted alternately, it was assumed e effect of the light on the one died away at the same t it increased on the other. The percentage of decrease tance of one plate would then equal the percentage of e in the other and the observed effect would be due to n of these two. The percentage of change in both which would produce a movement of the index equal caused by moving the slide one millimeter was calcu- us. If x is this percentage, then for plates A and B e ratio of the resistances in the box was 25 : 10—

$$\frac{1}{1100}:10-\frac{1}{1100}::25+\frac{25x}{100}:10-\frac{10x}{100} \quad \therefore x=\cdot006 \text{ per cent.}$$

and B′ when the ratio of the resistances in the box was

$$186:110 \qquad x=\cdot001 \text{ per cent.}$$

When plates A and B were illuminated by sunlight as mentioned above, they were connected as in this method. The change of resistance corresponding to a given deflection was therefore calculated as above, except that as the light was not shifted from one plate to the other, the effect must be considered as produced by a change in the resistance of one plate instead of being the sum of equal changes in two plates, x was thus found in this case to equal ·013 per cent. The per cent of change corresponding to any deflection D was of course $\frac{Dx}{S}$, S being the sensibility.

The light was shifted from one plate to the other by moving the lens every fifteen minutes. During the last five minutes of each exposure, observations of the first elongation of the index were made once a minute and the means taken. Care was taken to read the zero point before taking each elongation. The circuit was closed for a few seconds only of the fifteen minutes of exposure. Plates A B, A′ and B′ were thus treated. With plates C, D and E the method of observation was the same, but the bridge was arranged as at first, only one plate being connected at a time, and this plate was alternately lighted and darkened at intervals of fifteen minutes. The change in the resistance of the plate corresponding to a deflection of one scale division was calculated as in method I.

It should be noted that the method of Hansemann, before described, was also tried but was not successful for the reason that on account of the long exposures it was necessary to keep the circuit closed for several hours at a time, instead of for a few minutes only, as with Hansemann, and during this time the variation of the index from change in the zero point and accidental causes was considerable. In this method there was observed a steady increase of the plate resistance caused probably by the heating effect of the current, or it may be by the passage of the current itself as claimed by Börnstein.

Tables of Results (method I).

Deflection to right corresponds to diminished resistance; to left—to increased resistance.

Date.	Plate	No. of obs.	De-flec. to right.	To left.	Zero de-flec.	Max. de-flec.	R. a	r.	s.	n.	Per cent change for ¼ sc. div.	So'ce of light.	Re-marks.
1883. Feb. 13	B	12	--	--	12	--	$\frac{12}{3}$	100:10	1·8	266	·001	gas	No
14	B	12	--	--	12	--	$\frac{12}{3}$	100:10	4·3	265	·0006	gas	alum cell
15	B	12	--	--	12	--	$\frac{12}{3}$	100:10	1·9	274	·001	gas	used
19	B	12	--	--	12	--	$\frac{12}{3}$	100:10	1·3	268	·002	gas	
20	B	10	--	10	--	−1·5	$\frac{12}{3}$	100:10	1·8	271	·001	gas	
20	A	12	2	6	4	±1	$\frac{5\cdot5}{3}$	100:10	3·5	264	·001	gas	
22	A	20	2	10	8	−1	$\frac{5.5}{3}$	10:10	14·0	264	·004	gas	
22	A	11	1	3	7	--	$\frac{5.5}{3}$	10:10	16·0	264	·003	gas	

Date.	Plate	No. deflec-tions.	Mean deflec-tions.	Max. deflec-tions.	Per cent change for 1mm. Rh. wire.	r.	s.	n.	Per cent change corresp. to mean deflec'n.	So'ce of light.	Remarks.
Apr. 9	B	10	4·1	6	·013	25:10	10	1100	·005	sun	no alum.
9	B	10	2·	3	·013	25:10	10	1100	·003	sun	alum.
9	B	10	2·1	3	·013	25:10	10	1100	·003	sun	no alum.
9	B	5	2·	2	·013	25:10	10	1100	·003	sun	alum.
9	A	3	5·	6	·013	25:10	10	1100	·0065	sun	alum.

Date.	Plate.	No. obs.	Deflec. to right.	To left.	Zero deflec-tions.	Mean movement for 10 sec. no light.	Ditto Plate lighted.	Diff.	R. a.	r.	s.	n.	Per cent change corres. to diff.
Apr. 16	C	22	1	12	9	−0·7	−·86	−·16	9·3 × 1	100:10	3·7	265	inc. ·0002
19	D	19	4	9	6	−0·3	−·48	−·18	6·3 × 1	100:10	4·3	265	inc. ·0003
25	E	12	7	5	0	+·12	+·4	+·28	10·3 × 1	100:10	6·6	265	dim. ·0002
25	E	8	2	5	1	Movement for 5 seconds +·65	(5 sec.) +·13	−·52	10·3 × 1	100:10	6·6	265	inc. ·0003

Results.—Method II.

Date.	Sensibility.	Plate lighted.	Elongation. Mean of 5.	Diffs.	Per cent Inc. in resist. of Plate lighted.	Per in Pla
Mar. 20	5·4	A	− 2·7	----	----	
		B	− 2·7	0	0	
		A	− ·8	+ 1·9	----	
		B	− 1·1	− ·3	----	
		A	+ ·75	+ 1·8	----	
		B	+ ·2	− ·5	----	
		A	+ 1·9	+ 1·7	----	
		B	+ 2·4	+ 0·5	·0005	
Mar. 29	1·3	--	+ 1·1	----	----	
		B	+ 2·	+ 0·9	·004	
		A	+ 1·9	− 0·1	·0005	
		B	+ 2·1	+ 0·2	·001	
		A	+ 1·7	− 0·4	·002	
		B	− 0·9	− 2·6	----	
		A	− 4·2	− 3·3	·017	
		B	−11·1	− 6·9	----	
Apr. 2	10·2	--	− 1·1	----	----	
		A	− 1·5	− 0·4	·0002	
		B	− 3·9	− 2·4	----	
		A	− 4·7	− 0·8	·0005	
		B	− 4·4	+ 0·3	·0002	
		A	− 4·2	+ 0·2	----	
		B	−15·4	−10·8	----	
		A	−24·	− 8·6	·005	
Apr. 10	1·7	--	− 3·3	----	----	
		B′	+ 9·8	+13·1	·008	
		A′	+ 9·1	− 0·7	·0004	
		B′	+ 0·6	− 8·5	----	
Apr. 11	2·2	B′	+11·2	----	----	
		A′	+16·5	+ 5·3	----	
		B′	+51·8	+35·3	·016	
		A′	+42·	− 9·8	·004	
Apr. 12	2·5	--	− 0·7	----	----	
		B′	+ 6·9	+ 7·6	·003	
		A′	+ 0·3	− 6·1	·0024	
		B′	+17·	+16·2	·016	
		A′	−13·2	− 3·8	·004	
		B′	+20·6	− 7·4	·007	
		A′	−16·9	− 3·7	·004	
		B′	− 29·	−12·1	·012	

Results.—Method II—continued.

ate.	Remarks.	Plate.	Elongation. Mean of 5.	Diffs.	Per cent Inc. in resist. of Plate.	Per cent Dim. in resist. of Plate.
pr. 17	s=2·2	C				
	r=100 : 10	(Platinum)				
	n=265	light off	− 9·2			
	R=9·3	on	−10·9	− 1·7	·003	
	a=1·	off	−16·1	− 5·2	·009	
	1 sc. div.	on	−19·	− 2·9	·005	
	=·0018%	off	−19·1	− ·1	·0002	
	of plate					
Apr. 19	s=6·3	D				
	r=100:10	(gold)				
	n=265	light off	−12·2			
	R=6·3	on	− 4·1	+ 8·1		·008
	a=1	off	+ 1·9	+ 6·		·006
	. ˙ .	on	+ ·5	− 1·4	·0014	
	1 sc. div.	off	+22·3	+21·8		·022
	=·001%					
	plate					
pr. 26	r=100:10	E				
	n=265	(silver)				
	a=1	off	− 2·5			
	R=10·3	on	−18·	−15·5	·008	
	s=8	off	−36·	−18·	·009	
	1 sc. div.	on	−43·	− 7·	·004	
	=·0005%	off	−47·	− 4·	·002	
	of plate					
pr. 27	R=10·3	off	− 2·8			
	s=2·5	on	−16·5	−13·7	·022	
	1 sc. div.	off	−34·4	−17·9	·029	
	=·0016%					
r. 28	s=6	off	− 6·6			
	1 sc. div.	on	+ 2·4	+ 9·		·006
	=·0007%	off	+70·	+67·6	irregularity in needle.	
		off	− 1·5			
		on	+ 3·6	+ 5·1		·003
		off	+ 7·5	+ 3·9		·0024

SUMMARY OF RESULTS.

Instantaneous effect—(method I).

ate A	Increase of a few thousandths of 1 per cent.
B	No diminution of more than ·001 per cent.
B	(Sunlight) increase of ·004 per cent.
C	Increase of ·0002 per cent.
D	" ·0003 "
E	" ·00005 "

Long exposures—(method II).

A and B	Mean effect on plate lighted—	decrease of ·0014 per cent.
A′ and B′	" "	increase of ·0053 "

	Mean effect of lighting plate.		Of darkening.	
C	increase	·004 per cent	increase	·0046 per cent.
D	diminution	·003 "	diminution	·014 "
E	increase	·005 "	increase	·007 "

It will be seen that the above results agree with those of Siemens and Hansemann rather than those of Börnstein. The latter's objections to Siemens and Hansemann's methods have already been mentioned. The first, that the experiments were made on the plate when the circuit though it was closed, apply of course also to method I of the series just described. In Börnstein's experiments by the damping method however, his plates were traversed by a current, though of course a very feeble one, and it is difficult to see how the difference between a diminution of five per cent and no perceptible effect can be accounted for by the fact that the current in one case was intermittent and in the other constant.

Börnstein's second objection relating to the length of the exposure is worthy of more attention. The exposures of Siemens and Hansemann and those of method I, above, were for a few seconds only. It seems well established then that the effect of light on the electrical resistance of metals is not instantaneous, and this is admitted by Börnstein. But method II to which neither of Börnstein's objections apply,—since the plates were exposed for periods of quarter of an hour each, and the circuit closed for only a few seconds of this time—also shows no appreciable diminution and it is this which conflicts most directly with Börnstein's conclusions.

In the experiments described above the connections of plates A, B, A′ and B′ were made with special view to the prevention of any thermo-electric currents which might be generated at the junction of two different metals by unequal heating and which might by their effect on the galvanometer simulate a decrease of resistance. It may be here remarked, however, that in searching for an effect of any kind, many precautions which become necessary as soon as the effect seems to appear, in order to try whether it be real or simulated, need not be taken when no effect at all appears. Thus it was thought unnecessary to make all connections by means of mercury cups, and common binding screws were used.

It may also be here mentioned that the effect whose existence is to be proved or disproved is of course the difference between the effects of the light and the heat of the luminous ys. This is the quantity also measured in Siemens and ansemann's experiments. Börnstein on the other hand, who sed no alum cell, measured the excess of light effect over the eat effect of both luminous and obscure radiations, so that if here is a true diminution of resistance caused by light, it ught to have appeared more strongly in the experiments hich have been described.

Taking all these things into consideration, it appears safe to ay then that if light causes any diminution in the electrical esistance of metals, it probably does not exceed a few thousandths of one per cent.

ART. XIX.—*Vanadinite in Pinal County, Arizona;* by FRANCIS HAYES BLAKE.

THE rare mineral Vanadinite is found in the "Black Prince Mine," Pioneer Mining District, Pinal County, Arizona, in brilliant red and yellow hexagonal crystals. Qualitative tests show the presence of vanadium, chlorine and lead.

The crystals occur in the seams of a partly decomposed rock resembling trap, covering completely in some cases five square inches of surface. They vary in size from one sixty-fourth to one-eighth of an inch in diameter, sometimes reaching the length of one-quarter of an inch. They are often implanted by the side and are then doubly terminated. The majority of these crystals are of a deep red color; some vary from a red at one end through deepening shades of delicate straw-yellow to orange and red at the other end. Others exhibit a succession of layers of deep red and light yellow parallel to the basal plane. Many of the crystals are cavernous, and fibrous, resembling in their cavernous structure the prisms of pyromorphite. The prismatic planes *I* are striated vertically, which in this respect is just the opposite to what occurs in pyromorphite.

The simple hexagonal prism, without modifications, predominates as the crystalline form; although in some groups of crystals is found the combination of the two prisms *I* and *i*-2, with the basal edges replaced by planes of the pyramid of the first series. These planes are very minute. I was unable to find planes between *O* and *i*-2.

Wulfenite is also found in this mine but not in very perfect crystals.

Pinal, Pinal County, Arizona, June, 1884.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS AND CHEMISTRY.

1. *On the General Law of Solidification of Solvents.*—RAOULT has studied the effect which is produced upon the point of solidification of a solvent by dissolving solid, liquid or gaseous substances in it. If A represent the coefficient of depression, that is the amount by which the temperature of solidification is lowered when one gram of the substance is dissolved in 100 grams of the solvent; M the molecular weight of the anhydrous substances and T the molecular depression of the freezing point (that is, the depression corresponding to the solution of one molecule of the dissolved substance in 100 grams of the solvent) then $MA = T$. The solutions employed were very dilute, containing less than one molecule (in grams) of the solid to two kilograms of the solvent. The solvents used were water, benzene, nitrobenzene, ethylene dibromide, formic acid and acetic acid, whose freezing points were respectively 0°, 4·96°, 5·28°, 7·92°, 8·52° and 16·75°. The following are the conclusions reached: 1st, All bodies, whether solid, liquid or gaseous, when dissolved in a definite compound liquid, capable of solidifying, lower the point of congelation. 2d, There is for each solvent a maximum molecular depression of the freezing point. And 3d, With all solvents, the molecular depression of the freezing point, due to the different substances dissolved, approximates to two mean values, differing with the character of the solvent, one of which is double the other. Thus for ethylene dibromide these values are 117 and 58, for nitrobenzene 72 and 36, for benzene 49 and 24, for acetic acid 39 and 19, for formic acid 28 and 14 and for water 37 and 18·5. The greater of these two values, which the author calls the normal depression, is much the more frequent, except in the case of water. Since, with the same solvent, the substances producing either the normal or abnormal depression belong to well-defined groups, the depression observed may be made use of in fixing the molecular weight. All salts of the alkalies for example, when dissolved in water, produce a molecular depression of about 37; hence among many multiple values of the molecular weight of such a salt, that one is selected which multiplied by the coefficient of depression of the salt in water, gives a product nearest to 37. For organic substances soluble in water, that value is chosen which when multiplied by the coefficient of depression gives a value nearest to 18·5. The foregoing facts seem to the author to justify the following generalization: For a constant weight of a given solvent, all physical molecules of whatever nature, produce the same depression of the freezing point. When the bodies dissolved are completely disaggregated, as for example, when they are in the state of vapor, so that each physical molecule contains only a single chemical molecule, the

olecular depression is a maximum and the same for all bodies.
hen the chemical molecules are united in pairs to form the
hysical molecule, the depression has only one half its former
alue, since the double molecule produces no more effect than the
ngle one. If the maximum molecular depression be divided by
e molecular weight of the solvent, the quotient expresses the
epression produced when one molecule of the substance is dis-
lved in 100 molecules of the solvent. This value is for formic
cid 0·63, for acetic acid 0·65, for benzene 0·64, for. nitrobenzene
·59, and for ethylene dibromide 0·63; being practically the same
r all. For water however, the value is 2·61, a value four times
o large. This the author explains by the hypothesis that the
hysical molecule of water consists of four chemical molecules.
he general law of solidification of solvents, Raoult enunciates
nally as follows: If one molecule of any substance be dissolved in
0 molecules of any liquid, of a different nature, there is produced
depression in the freezing point of the liquid which is always
bout the same and approaches very near the value 0·63. Conse-
uently, the depression of the freezing point of a dilute solution, of
hatever sort, is sensibly equal to the product which is obtained by
ultiplying the number 63 by the ratio between the number of
olecules dissolved and the number of the dissolving molecules.

In subsequent papers, Raoult considers the application of this law to the study of the distribution of acids and bases in solution, and of the freezing point of acid and alkaline solutions. With reference to the latter, he concludes as follows: Acids and bases in this respect, may be sharply divided into two groups. The first comprises those which produce a normal molecular depression of the freezing point near 40°. The second includes those acids and bases which produce an abnormal molecular depression near 20°. The bases of the first group are all analogous to potassium hydrate and, like it, are capable of displacing from their chlorides all the bases of the second group. The acids of the first group are all strong acids like hydrochloric acid, and like it, are capable of displacing from their alkali-salts all the acids of the second group.—*Ann. Chim. Phys.*,VI, ii, 66, 93, 99, 115, May, 1884.

G. F. B.

2. *On the Production of Cyanides and Ferrocyanides from Trimethylamine.*—On calcining the residue from the distillation of alcohol made by the fermentation of beet-root molasses, there is produced, as Vincent has shown, a large quantity of trimethylamine; one establishment at Courrières producing 1800 kilograms of trimethylamine salts per day from this source. Some time ago Ortlieb and Müller modified the Solvay process so as to adapt it to the preparation of potassium bicarbonate from the chloride, by using trimethylamine in place of ammonia; carbon dioxide gas being passed through a saturated aqueous solution of
ne molecule of normal trimethylamine carbonate and two of
otassium chloride at 23°, until potassium bicarbonate, represent-
g nearly 40 per cent of the chloride, was precipitated. These

same chemists have now introduced into the chemical works at Croix a process for the manufacture of cyanides from trimethylamine. On passing this substance through a red hot porcelain tube, it is decomposed and yields hydrogen cyanide, ammonium cyanide and hydrocarbon gases. On the large scale, retorts are used like those employed in the manufacture of gas, and the products are passed, first through dilute sulphuric acid to retain the ammonia and then through caustic alkali to absorb the hydrogen cyanide. The gases are collected in a gasholder and used for illumination. To prepare the ferrocyanides, a known quantity of ferrous oxide is dissolved in the alkali-cyanide solution, obtained as above.—*Bull. Soc. Ch.*, II, xli, 449, May, 1884.

G. F. B.

3. *On the Preparation of Marsh Gas.*—Some years ago, GLADSTONE and TRIBE pointed out that by the reaction of the copper-zinc couple upon methyl iodide in presence of water or alcohol, marsh gas was readily produced, as follows:

$$CH_3I + H_2O + ZnCu = CH_4 + ZnI(OH) + Cu.$$

These chemists have now devised a process by which this reaction may be used for the preparation of marsh gas without the large loss at first experienced. 550 grams of somewhat thinly granulated zinc were placed in a 600 c.c. flask, and 150 grams in a glass tube one inch in diameter and twelve inches long. This tube was fixed above the flask like an inverted condenser. After cleaning the zinc with dilute sulphuric acid, it was treated three times with a solution of copper sulphate until all the copper had been precipitated on the zinc, and then well washed, first with water and then with alcohol. The apparatus was then put together and by means of a tap funnel opening into the flask 20 c. c. of methyl iodide and the same volume of alcohol were allowed to run into the latter upon the copper-zinc couple. The reaction began at once, the first liter of marsh gas being collected in eight minutes. As a result 7500 c. c. of the gas was obtained, or 7053 c. c. reduced to normal temperature and pressure. As the theoretical yield is only 7100 c. c. the process gives about 99·3 per cent of the total quantity obtainable. The operation can be shortened by raising the temperature. Vapors of methyl iodide and alcohol accompany the gas.—*J. Chem. Soc.*, xlv, 154, May, 1884.

G. F. B.

4. *On the Crystalline Form of Beryllium.*—BRÖGGER and FINK have examined the crystalline form of metallic beryllium. The crystals were exceedingly minute, the faces having a breadth of only 0·005 to 0·001 millimeter. They were very brilliant and of a steel-gray color. On examination they proved to be holohedral forms belonging to the hexagonal system, the ratio of the axes being 1 : 1·5802 as calculated from the angle between the basal plane 0P and the pyramid P, which was 118° 43½′. The faces observed on specimens furnished by Nilson and Pettersson were: ∞P, ∞P2, 0P, P; and in addition, on the specimens from

Pettersson and Humpidge, the pyramid ½P. The authors think the analogy close between beryllium and zinc, the latter being in all probability holohedral.—*Ber. Berl. Chem. Ges.*, xvii, 849, April, 1884. G. F. B.

5. *On the Vapor-density of Beryllium Chloride.*—The importance of the atomic weight of beryllium in connection with the periodic law, has led Nilson and Pettersson to undertake the determination of the vapor density of its chloride. This compound was prepared by heating the metal in a current of dry hydrogen chloride gas. But as its vapor corrodes glass the operation had to be conducted in a narrow tube of platinum. The chloride is an easily fusible and volatile snow-white mass, made up of minute crystals sometimes transparent. To determine the vapor density a platinum tube was enclosed in a tube of difficultly fusible glass and placed in an iron tube in an ordinary combustion furnace side by side with another similar tube containing an air thermometer. The expelled gases were measured on separate manometers. Since the chloride loses chlorine in presence of air, the tube and manometer were filled with carefully dried carbon dioxide before it was introduced. The vapor densities were, at 490°, 6·7; at 520°, 4·174; at 589°, 3·067; at 597°, 3·031; at 604°, 3·090; at 686°, 2·853; at 720°, 2·926; at 745°, 2·753; at 812°, 2·793. The calculated vapor density is for Be''' 13·65 and Be_2Cl_6 8·310, $BeCl_3$ 4·155. For Be'' 9·10 and $BeCl_2$ 2·770; and for Be' and BeCl, 1·385. Hence in the state of a perfect gas, from 686° to 800°, the molecule of beryllium chloride is represented by the formula $BeCl_2$ and the atomic weight of beryllium must be considered as 9·10.—*Ber. Berl. Chem. Ges.*, xvii, 987, May, 1884. G. F. B.

6. *On Anthemene, a hydrocarbon from Chamomile.*—In examining the residue from the evaporation of the solvents used in the extraction of the flowers of chamomile (*Anthemis nobilis*), Naudin discovered two white crystalline solids, separable from each other by treatment with cold absolute alcohol. The one least soluble fused at 63°–64°; the other at 188°–189°. From a kilogram of the flowers, 1·5 grams of the former and 4·5 grams of the latter were obtained. The former body only has been examined. It crystallizes in fine microscopic needles without odor or taste, boils at 440° and has a specific gravity of 0·942. It is insoluble in water but soluble in ether, ligroin, carbon disulphide, chloroform, etc. On elementary analysis it afforded, as a mean of many accordant analyses, carbon 83·80, hydrogen 14·40=98·20; a loss of 1·80 per cent. Repeated by Schützenberger, the analyses still showed a loss of 1·53 per cent. The formula $C_{18}H_{36}$ requires 85·82 carbon and 14·18 hydrogen. Its vapor density was found to be 127. The author is inclined to consider it as an octodecene with a closed chain; and proposes to call it β-octodecene or anthemene.—*Bull. Soc. Ch.*, II, xli, 483, May, 1884. G. F. B.

7. *On Lactosin, a new Carbohydrate.*—Meyer has described a new carbohydrate closely resembling dextrin and which seems

to play the same part in the caryophyllaceæ that inulin does in the compositæ. It was obtained from the roots of ***Melandryum album*** G. and of ***Silene vulgaris*** G. by precipitating the juice first with a small quantity of alcohol to separate the proteids and then with a larger quantity to precipitate the new body. After preliminary purification, it rotated to the right $(\alpha)_D = +168°$ and finally $+190°$. After boiling with 80 per cent alcohol, it crystallized in small brilliant crystals. On inversion it gives lactose and a new difficultly crystallizable sugar. The formula $C_{36}H_{62}O_{31}$ is assigned to it and the name lactosin.—*Ber. Berl. Chem. Ges.*, xvii, 685, April, 1884. G. F. B.

8. *A method of determining the Standard of Light adopted by the Paris Conference.*—The International Conference lately held at Paris adopted as a standard of light the amount emitted by one square centimeter of melting platinum at the point of solidification. WERNER SIEMENS points out that the practical determination of this unit is beset with difficulties, since platinum at the melting point readily takes up foreign substances which change this melting point. He therefore recommends the use of the following apparatus, which, however, determines the light given out by the platinum at the point of melting and not at the point of solidification. With pure platinum, however, the difference is very small. The method is based upon the melting of a very thin plate of platinum by a current of electricity. The platinum is enclosed in a metallic case provided with a hole 0·1 square centimeter in section, which is immediately over the melted platinum. The sides of this hole are conical and the platinum foil extends beyond the hole in every direction. At the instant of the melting of the foil a quantity of light equal to 0·1 of the standard is emitted from the hole. By suitable modification of the strength of the electrical current the melting of the platinum can be delayed until the proper moment of comparison with another light has arrived. Preliminary measurements with this apparatus show that the light emitted from the hole at the point of melting of the platinum is about 1·5 times the English standard candle.—*Ann. der Physik und Chemie*, 1884, No. 6, p. 304. J. T.

9. *The boiling point of Oxygen, of Air, and of Carbonic oxide under atmospheric pressure.*—M. S. WROBLEWSKI has shown that a fall of temperature of $-186°$ C. can be obtained by the expansion of liquid oxygen. In continuing his work he discovered that a hydrogen thermometer of small size could not be depended upon, and therefore adopted a thermo-electric apparatus, using an aperiodic galvanometer of large resistance and great sensibility. The inductions of this electrical apparatus were afterwards compared with a large hydrogen thermometer. By this method working at the low temperature of $-200°$ C. the $\frac{1}{200000}$ of a volt could be measured. This corresponds to a change of $\frac{1}{5}$ of a degree of temperature. With this apparatus the author has been enabled to measure the boiling point of oxygen, of air, of nitrogen and of carbonic oxide under the ordinary pressure.

These gases are obtained as liquids by leading them from a metalic receiver, where they are already compressed to 100 atmospheres, into a glass tube closed at one end and immersed in iquid oxygen. On the expansion of the oxygen, the compressed gas is liquefied. When the expansion is accomplished the connection of the tube with the receiver is broken, and it is brought slowly to the atmospheric pressure; the liquid gas boils at a temperature corresponding to this pressure. M. Wroblewski obtains the following results:

Oxygen, boiling point	$-184°$ C.
Air, " "	$-192{\cdot}2°$
Nitrogen, " "	$-193{\cdot}1°$
Carbonic oxide,	$-193°$

On evaporating these gases *in vacuo* a temperature of $-200°$ C. can be obtained. It results from the above that ordinary air promises to be the refrigerator of the future. It does not require to be prepared; to use it, it should first be compressed to the point of liquefaction in metallic receivers. It should then be allowed to pass into the receivers already cooled when it will be liquefied, and it can then be allowed to flow out. This use of air involves no technical difficulties, and success depends only upon the material means at the disposal of the experimenter.—*Comptes Rendus*, April 21, 1884. J. T.

10. *The Scientific Papers of James Prescott Joule, D.C.L., L.L.D.*, etc. 657 pp. 8vo. London: 1884. (Taylor & Francis.)—The Physical Society of London has done a most important work for the advancement of physical science in collecting and reprinting the papers of Dr. Joule, and thus putting them in convenient form for the use of students and workers. The importance and lasting value of Dr. Joule's contributions to Physics are so well known that this collection must be at once received with the appreciation which it deserves. The papers included are arranged in order of publication and number about one hundred, some of which, however, are very brief. The most important of the memoirs are those devoted to the discussion of the experiments by which the mechanical equivalent of heat was determined, a subject with which the name of Dr. Joule will always be connected; in first proving the existence of this relation and then determining its value, and that with a marvelous degree of accuracy, Dr. Joule made a contribution to the advance of physical science which is second to no other in the history of the science. A considerable number of the papers in the volumes are more or less closely related to this subject. Some of the other more important memoirs are on specific heat; on the effect of magnetism on the dimensions of iron and steel bars; on the thermo-dynamic properties of solids; on the surface condensation of steam. This volume is soon to be followed by a second containing papers published by Dr. Joule in conjunction with other men of science.

11. *Whirlwinds, Cyclones and Tornadoes;* by WILLIAM M. DAVIS. 90 pp. 16mo. Boston: 1880. (Lee & Shepard.)—The author has presented in this little volume (reprinted from Science)

a brief but clear and readable statement of the theory of storms. The subject is one which now compels serious attention in certain parts of the country, and this concise exposition is consequently very opportune.

II. GEOLOGY AND NATURAL HISTORY.

1. *The Kame Rivers of Maine;* by GEORGE H. STONE, of Colorado Springs, Colorado. (Abstract from the Proc. Amer. Assoc., 1883.)—Nearly all glacialists now agree that most of the kame gravels of the drift region were deposited by glacial streams. There remains a difference of opinion as to whether these streams were sub- or super-glacial; but for the sake of brevity no reference is here made to the literature of the subject. In my studies of the drift in Maine, I think I have found evidence of both kinds of streams.

During an exploration of Maine which continued for about five years, I had opportunity to examine many thousands of sections of the till throughout the greater part of the state. I have never found stratified or even water-classified material enclosed in this formation, except within a few miles of the coast, or so near to the surface as to leave the interpretation in doubt. Hundreds of miles of the beds of the inland streams have been examined by me, and if water-washed material exists in the till in the interior of the state, it must be rare. But near the coast, as for instance at Portland, one may see small masses of sand nearly or quite surrounded by the unmodified till, the clayey till being in such contrast with the clean, siliceous sand, that the difference in composition and mode of formation is seen at once unmistakably. These masses of sand and gravel in the till are often not now stratified, but all have been plainly classified by running water and not afterward so mixed with the clayey till as to lose their identity, If a ribbon or pocket of sand, not an inch in thickness, can be thus plainly distinguished from the amorphous till, surely the absence of such deposits from the great interior region is strong indication that the conditions were there different from what they were near the coast. A somewhat positive indication of what this difference was is found in the existence of pot-holes near the coast in situations where no ordinary surface streams can ever have flowed. These pot-holes must be regarded as the work of glacial streams. In the interior no pot-holes have been found except in the valleys of ordinary streams.

Before interpreting these facts, let us consider the causes of the melting of a glacier. The white color and porous structure of the surface ice of a glacier show where most of the melting takes place. This superficial water flows along the surface, or it may wear and melt a deeper and deeper channel until it disappears down some crevasse and becomes a sub-glacial stream. Modern glaciers show a difference in their glacial streams. Near the lower extremity almost all the water is sub-glacial. The ice is so broken by crevasses that the melting waters almost immediately plunge to the bottom. But as we go backward toward the line of perpetual snow, where the ice is thicker and the melting less rapid, we find streams upon the surface, the length depending upon the extent of ice free from crevasses. How far do these conditions represent those of the great glacier of eastern North America?

Without some limitation, it is doubtful if the analogies of any modern glaciers, even of Greenland glaciers, can be admitted as valid in the case of the great ice-sheet. The Greenland glaciers do not wholly overlap large areas like the great ice-sheet, but here and there peaks emerge from them which form crevasses and assist the waters to pass beneath the glacier. However, waiving these objections, and admitting for the time that the sub-glacial streams of our great glacier were as well developed as those of the Greenland glaciers of to-day, at the same time we must admit that the surface streams were as well developed. Now the superficial streams of the Greenland glaciers are often of considerable size; therefore we must believe that large surface streams existed upon the ice-sheet at a proper distance north from its terminus. It should be noted that this is the condition of the Greenland glaciers during a time of comparative stability, or, quite probably, of their slow increase in extent and depth.

But what would happen during the final melting of the ice-sheet? All substantially admit that this melting was very rapid and that it took place upon a great width simultaneously, although the ice, being thicker toward the north and in a colder mean climate, would not become melted so quickly as farther south. As I have elsewhere pointed out, no southward motion would be possible over a large part of Maine, after the thickness of the ice was reduced to about five hundred feet, on account of transverse ranges of hills. Nowhere except in the White Mountains have I found traces of glaciers following local valleys. Apparently, almost all flow ceased after the melting had so far proceeded that the hills appeared above the ice. Under these conditions no new lines of crevasses would open in the thinning ice-fields, even after the hills began to emerge. The melting took place so rapidly, and the motion of the ice ceased so completely that there would be no time for the formation of sub-glacial channels. On the contrary, the exigency of glacial melting, supplemented by the summer precipitation, would cause a great extension of the superficial streams.

The presence of glacial pot-holes in Maine near the coast, and the masses of water-washed matter in the till, show that the glacial streams there reached the ground. The most of the area of sub-glacial streams must have lain south of the present coast-line. The glacier reached out into the Gulf of Maine, and off its front were probably numerous boiling springs of fresh water, like those at the submerged extremities of the Greenland glaciers. The ice over the great interior region of the state was for the most part drained by superficial streams. When the melting had so far proceeded that the bottoms of these streams reached the moraine stuff, which was scattered through the lower part of the ice, then the kame-gravel began to gather on the bottoms of their channels. Several of these kame-rivers were a hundred or more miles long, as is shown by my map of the kames of Maine, published in the Proceedings of the Association for 1880. Most of the kame-rivers have been described by me as probably flowing in channels formed superficially on the ice, and that is my opinion still. Near the coast these channels may originally have been of sub-glacial origin. Northward there was a region where the drainage of the glacier was chiefly by surface channels which finally found their way beneath the ice at the southern limit of this region. The final melting of the great glacier took place largely at the surface, and this melting, together with the large rainfall, caused great bodies of water to collect on the ice, finally wearing and melting deep channels. In some cases these streams probably followed previously formed sub-glacial channels for a part of their course, widening them until the ice-arch collapsed by its own weight.

We may grant as great a development of sub-glacial streams in the ice-sheet as anyone can reasonably consider is demanded by the Greenland glaciers, and yet I cannot see how this furnishes any adequate representation of the conditions during the final melting, when there was so vast an accession of surface water, and also when the ice-flow had so far ceased as to make it certain that few if any additional crevasses would be formed. Under these circumstances there could be no time to extend the previously formed sub-glacial channels far, and the sudden floods would find their way over the lowest parts of the ice just as they would over the ground. A great and sudden northward extension of the superficial streams would be the result.

The above reasoning applies to Maine only, and other regions are to be studied by themselves. Part of the reasoning will probably apply to most or all of the glaciated area of North America, but with many differences in details. Indeed, as glacialists come to better appreciate the great variety of work which the ice-sheet performed, the less likely will they be to contend for the privilege of imposing the local conditions, with which we are most familiar, upon the whole drift-covered area.

2. *Notes on Tertiary Shells*; by OTTO MEYER (Proc. Nat. Sci. Philad., 1884, p. 104).—Mr. Meyer, who is well versed in the Tertiary paleontology of Europe through his studies and investigations, gives the results in this paper of his examination of certain American species. He identifies *Terebra constricta* H. C. Lea, and *Cerithium terebralis* Adams (a living New England species) with *Cerithium trilineatum* Phil., of Great Britain, France, Belgium, Germany, etc., and living in the Mediterranean; *Pleurotoma cristata* Conr., *Cochlespira bella* Conr., *C. engonata* Conr. with *Pleurotoma Volgeri* Phil., of nearly the same wide range abroad; *Saxicava bilineata* Conr. with *Saxicava arctica* L., of wide distribution, and now living on both sides of the Atlantic; and confirms Heilprin's identification of *Pleurotoma*

Beaumonti Lea with *P. denticula* Bast., after comparison with German specimens of the latter. Mr. Meyer also describes the new Claiborne species *Tibiella Marshi*, *Bulla biumbilicata*, *Cadulus depressus*. Mr. Meyer states further that in his opinion, and also Professor Verrill's, *Cadulus Pandionis* of Verrill and Smith, from the western part of the Atlantic, is identical with *Cadulus thallus* named *Dentalium thallus* by Conrad, from the Miocene of the Southern States; and that if Jeffreys is right, this species is identical with *Cadulus Olivi* of Scacchi from the Pliocene of Sicily. It is to be hoped that Mr. Meyer may be able to continue his study of American Tertiary fossils.

3. *The Geological and Natural History Survey of Minnesota, 11th Annual Report*, N. H. WINCHELL, State Geologist. 220 pp. 8vo. Minneapolis, 1884.—This report is occupied chiefly with a report on the minerals of the State by Mr. Winchell, on the crystalline rocks by Messrs. A. Streng and J. H. Kloos, and on the glacial and related phenomena of the Winnipeg region ("Lake Agassiz") by Mr. Warren Upham. The first of the reports states that gold has been washed from the drift at Rochester, Oronoco, Spring Valley, Jordan, in Fillmore County, and at several points in Wabasha County, and has been announced as taken from the gravel at Willmar.

4. *B. Lotti, of the Italian Geological Survey, on the origin of Tuscan Granite* (R. Com. Geol. d' Italia).—Signor LOTTI, of Pisa, reaches the conclusion that the Tuscan granite is largely of metamorphic origin; that the granite, for example, of Mt. Capanne, on Elba, was formed largely at the expense of a rock which is "gneissic schist" elsewhere, and that whilst the conversion of the rock into granite is general on the western side of Elba, it is only partial on the eastern. The reduction of the rock, as he observes, to a pasty state through the metamorphic process determined the formation of the granite, and also of veins of granite through its protrusion into fissures in the schistose rocks.

5. *Manual of the Mosses of North America;* by LEO LESQUEREUX and THOMAS P. JAMES. With six plates illustrating the Genera. Boston: S. E. Cassino & Co. 1884. pp. 447, post 8vo. —At length this much-needed and long-promised volume is in the hands of botanists and students, and the department of Bryology, so far as concerns the orders of the Peat-Mosses, Schizocarpous Mosses and True Mosses, is provided for. As long ago as the year 1848, and so far as relates to the Northern United States, some provision was made for their study, in the first edition of Gray's Manual, by a contribution from Mr. Sullivant, the founder of bryological study in this country. And when, in 1856, that work passed to a second edition, about 100 pages of this were devoted to a reëlaboration of the Mosses and the Liverworts by the same friendly and able hand. Mr. Sullivant also contributed eight admirable copper-plates, crowded with figures. This contribution, also separately issued in a small edition, did excellent service. It was thought best to drop these lower Cryptogamia

from later editions of the Manual, on the understanding that Mr. Sullivant, on the completion of his sumptuous *Icones Muscorum*, would prepare a synopsis of all the North American Mosses. But early in the year 1873, just as this accomplished bryologist was setting himself to the task, he was taken away by an attack of pneumonia. The authorship of this work was to be shared with his associate and near friend, Mr. Lesquereux. But Mr. Lesquereux was deeply engaged in paleo-botany, and could only from time to time snatch some moments for bryology. When the time arrived in which he could seriously give himself to this work, his eyesight was so impaired that he could seldom use the microscope. He now solicited the coöperation of the late Mr. James, an acute bryologist, who, being comparatively free from other engagements, could devote himself to the microscopical investigation and illustration of Mosses, in which he had long been an adept. With this important accession the preparation for this work went on successfully until, in February, 1882, Mr. James, who had reached his 79th year, suddenly died, and the work again devolved upon our aged and sole surviving bryologist. But at length, with the generous and needful editorial aid of Mr. Sereno Watson (which is gracefully acknowledged in the preface), the work is at length completed and published. It is handsomely printed, in a type which we should consider needlessly large. Mr. Sullivant's five copper-plates of the Mosses are well reproduced by transfer from the coppers, and a sixth is added for the Hypnoid genera or subgenera, taken from Schimper. An acknowledgment was due to the Sullivant family for the use of these plates, the omission of which was evidently a pure oversight. As to the genera, Schimper is closely followed. This was natural; but if the authors could have followed their own convictions the genera would probably have been fewer, more easily recognizable, and more accordant with the idea of genera in phænogamous botany. We may hope that this loss of a sense of proportion—a malady incident to specialists—will some day be remedied, and that genera in Mosses will again be characterized upon the organs of fructification rather than upon the shape of the cells of a leaf. It would have been well to have marked the principal accent of the generic and specific names. But we will not find fault with a work for which we cannot be too thankful. Let us rather felicitate the venerable and sole survivor of our four bryologists, Sullivant, Lesquereux, James and Austin, upon this worthy conclusion of his labors; and let us hope that, under the stimulus of their example and by the aid offered in their works, and which is brought within the reach of all in this manual, a new generation of bryologists may spring up. This is still a matter of hope, not at all of sight. A. G.

6. *Synopsis of the Genera of Vascular Plants in the vicinity of San Francisco, with an attempt to arrange them according to Evolutionary Principles*; by H. H. Behr, M.D. San Francisco: Payot, Upham & Co. 1884. pp. 165, 18mo.—The genera of a

limited district offer a small base for the development of "the idea of a classification founded on the phases of vegetable evolution;" still it may serve the author's purpose as well as a broader one would have done. The genera are said to be taken chiefly from "Dr. Asa Gray's Flora Californiensis." The title of the work thus referred to is the Botany of California, and the botanist mentioned as the author was only a contributor. A. G.

7. BOISSIER'S *Flora Orientalis.*—The second part of the fifth volume was issued in April, 1884. It contains the *Gramineæ,* the *Gymnospermæ,* and the Vascular *Cryptogamia,* and so brings this great undertaking to completion, except for a supplement to the earlier volumes, upon which the indefatigable author is now engaged. The first volume was published in the year 1867. We need not wait for the soon-expected supplement before we offer our congratulations to the author for this happy completion of this task of twenty years, the more remarkable because accomplished single-handed. A. G.

8. *Contributions to the Flora of North Patagonia;* by JOHN BALL, F.R.S., etc.—An article in the Journal of the Linnean Society, vol. xxi (1884), founded on a collection made by an amateur, M. Claraz, a Swiss gentleman; to which is prefixed some interesting remarks on the climate and indigenous botany of the region.

"The most remarkable feature in the flora of this region is its extreme poverty. . . . Putting together all that has been collected and published in Europe, I doubt whether more than 300 indigenous species can be said to be certainly known to grow south of the Rio Colorado. . . . It is certain that the extreme poverty of the flora of such an extensive continental area is a fact quite exceptional. . . . The causes of this poverty do not seem to me to have been adequately explained. Professor Lorentz is disposed to attach most importance to the uniformity and sterility of the soil and the rudeness of the climate. The soil of the plateau is no doubt both very uniform and very sterile; but similar tracts in other parts of the world support a very varied vegetation, and Engler has assigned good reasons for believing that dry soils are in general favorable to the development of new vegetable forms. Further, it may be remarked that the soil of the valleys must exhibit a sufficient degree of moisture, of constituents, and of exposition to favor the development of many species not yet established there.

"Still less can I admit the severity of the climate as an explanation of the poverty of the flora." And the author proceeds to demonstrate that the rainfall is not very scanty and is spread pretty uniformly over the seven warmer months of the year; and that neither the summer's heat nor the winter's cold are excessive.

"The true explanation, in my opinion, of the exceptional poverty of the Patagonian flora is to be sought in the direction long ago indicated by Charles Darwin, when, in discussing the absence of tree-vegetation from the pampas, he remarks that in that region, recently raised from the sea, they are absent, not because they cannot grow and thrive, but because the only country from which they could have been derived—tropical and sub-tropical South America—could not supply species to suit the soil and climate. So it happened in Patagonia—raised from the sea during the latest geological period, and bounded on the west by a great mountain range mainly clothed with an alpine flora requiring the protection of snow in winter, and the north by a warm temperate region whose flora is mainly of modified sub-tropical origin—the only plants that could occupy the newly-formed region were the comparatively few which, though developed under very different conditions, were sufficiently tolerant of change to adapt themselves to the new environment. The flora is poor, not because the land cannot support a richer one, but because the only regions from which a large population could be derived are inhabited by races unfit for emigration. The rapidity with which many introduced species have spread in this part of South America is perhaps to be accounted for, less by any special fitness of the immigrant species, than by the fact that the ground is to a great extent unoccupied."

The published list adds two or three to the considerable number of species in temperate South America—especially on the eastern side—which are identical with temperate North American species.

A. G.

9. *Change of the generic name Solenotus;* by ALFRED C. STOKES, M.D. (Communicated.)—In the July number of this Journal, on page 38, the writer describes a new genus of Infusoria under the name *Solenotus*, not being aware at the time that it was preoccupied. As a change is necessary I substitute the word *Notosolenus* (*νῶτος*, back; *σωλήν*, groove), the species then standing *Notosolenus apocamptus* and *N. orbicularis*.

Trenton, N. J.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Prehistoric man in Egypt and Syria;* by DR. DAWSON. (Proceedings of the Victoria Philosophical Institute of London, May, 1884.)—In dealing with his subject, Dr. Dawson remarked that, great interest attaches to any remains which, in countries historically so old, may indicate the residence of man before the dawn of history. In Egypt, nodules of flint are very abundant in the Eocene limestones, and, where these have been wasted away, remain on the surface. In many places there is good evidence that the flint thus to be found everywhere has been, and still is, used for the manufacture of flakes, knives and other implements. These, as is well known, were used for many purposes by the ancient Egyptians, and in modern times gunflints and strike-lights still continue to be made. The débris of worked flints found on the surface is thus of little value as an indication of any flint-folk preceding the old Egyptians. It would be otherwise if flint implements could be found in the older gravels of the country. Some

of these are of Pleistocene age, and belong to a period of partial submergence of the Nile Valley. Flint implements had been alleged to be found in these gravels, but there seemed to be no good evidence to prove that they are other than the chips broken by mechanical violence in the removal of the gravel by torrential action. In the Lebanon, numerous caverns exist. These were divided into two classes, with reference to their origin; some being water-caves or tunnels of subterranean rivers, others sea-caves, excavated by the waves when the country was at a lower level than at present. Both kinds have been occupied by man, and some of them undoubtedly at a time anterior to the Phœnician occupation of the country, and even at a time when the animal inhabitants and geographical features of the region were different from those of the present day. They were thus of various ages, ranging from the post-Glacial or Antediluvian period to the time of the Phœnician occupation. Speaking as a geologist, from a purely geological point of view, and from a thorough examination of the country around, there was no doubt but what there was conclusive evidence that between the time of the first occupation of these caves by men—and they were men of a splendid physique—and the appearance of the early Phœnician inhabitants of the land, there had been a vast submergence of land, and a great catastrophe, aye a stupendous one, in which even the Mediterranean had been altered fron a small sea to its present size. In illustration of this, the caverns at the Pass of Nahr-el-Kelb and at Ant Elias were described in some detail, and also, in connection with these, the occurrence of flint implements on the surface of modern sandstones at the Cape or Ras near Beyrout; these last were probably of much less antiquity than those of the more ancient caverns. Dr. Dawson's address was illustrated by flint implements and bones collected by him during his recent tour in the East.

2. *New England Meteorological Society.*—This society has recently been organized in Boston with the aim of advancing the science of meteorology and bringing into coöperation the many observers and students of the weather in New England. At the outset, it is proposed to institute a relatively limited system of observations at as many stations as possible, probably not going beyond rainfall and temperature range; but with the successful growth of the society, the plan of work will be enlarged. Mr. Winslow Upton, lately of the U. S. Signal Service, now Professor of Astronomy at Brown University, will act as director of observations; and early in the autumn, the council of the society hopes to begin the issue of a monthly bulletin summarizing the results obtained. All persons interested in the aim of the society, whether they can take part in the work of observation or otherwise give support to its objects, are invited to send their names to W. M. Davis, Secretary, Cambridge, Mass.

Transactions. Vol. 1.—The Royal Society of Canada consists of

3. *Royal Society of Canada*, 1882 *and* 1883. Proceedings and

four sections. I, French Literature, History and allied subjects; II, English Literature, History and allied subjects; III, Mathematical, Physical and Chemical sciences; IV, Geological and Biological sciences. This first volume contains 16 papers in section I, 9 in section II, 24 in section III and 24 in section IV, showing great scientific activity in the academy during its first two years. Some of the papers have already been noticed in this Journal.

4. *Royal Society of New South Wales*, vol. xvi, 1882.—Mr. A. LIVERSIDGE describes in this volume the Deniliquin or Baratta meteorite. H. Tenison-Woods is disposed to refer the extensive sandstone formation of eastern Australia, named the Hawkesbury Sandstone, chiefly to wind transportation, an opinion the writer's observations (Wilkes Expl. Exped. Geol., 1849) do not appear to him to sustain. The same author describes Mesozoic fossils from Palmer River, Queensland. Mr. H. C. Russell has a paper on Tropical rains illustrated by maps.

Census Reports on Cotton, E. W. Hilgard, Special Agent in charge:

(1) General Discussion of the Cotton Production in the United States, by E. W. Hilgard.

(2) On the Cotton Production and Agricultural features of Mississippi and Louisiana, by E. W. Hilgard.

(3) Physical and Agricultural features of California, with a discussion of the present and future of Cotton production in the State; also Remarks on Cotton Culture in New Mexico, Utah, Arizona and Mexico, by Dr. E. W. Hilgard.

(4) On the Cotton Production and Agricultural features of Georgia, Texas, Arkansas and the Indian Territory, by Dr. R. H. Loughridge, Special Census Agent.

(5) On the Cotton Production and Agricultural features of Alabama and Florida, by Dr. Eugene A. Smith, Special Census Agent.

Geological and Mineral Studies in Nuevo Leon and Coahuila; by Dr. Persifor Frazer. 36 pp. 8vo, with maps. Philadelphia, 1884.

Types of Animal Life selected for Laboratory use in inland districts; by C. L. Herrick. Part 1, Arthopoda. 34 pp. 8vo, Minneapolis, 1883.

German Upper Devonian Phyllopod Crustaceans. Professor J. M. Clarke (of Northampton, but for the year past in Germany) has described and figured, in the Jahrb. f. Min., i, 1884, three species of *Spathiocaris* and one of *Entomis*, from Bicken, and one of *Dithyrocaris* from Wildungen.

Der Tarsus der Vögel und Dinosaurier, eine morphologische Studie; von Dr. Georg Baur, aus München. 44 pp. 8vo, with two plates. An important paper.

Niagara fossils; by J. W. Spencer. 62 pp. 8vo, with several plates; including Graptolitidae and Stromatoporidæ of Upper Silurian, and fifteen new species of Niagara fossils. May, 1884. Printed for the Museum; also Proc. St. Louis Acad. Sci., vol. iv, no. 4. St. Louis, 1884.

The succession in the Archæan rocks of America compared with that in the Pre-Cambrian rocks of Europe, by Henry Hicks, F.G.S. Proc. Geologists' Assoc., vol. viii, no. 5.

Geology and Mineral Resources of the James River Valley, Va.; by J. L. Campbell, Professor Geol. and Min., Lexington, Va.; 120 pp. 8vo, with a map and Geological Sections. The work is a contribution to general as well as economic geology.

OBITUARY.

FERDINAND VON HOCHSTETTER, the able geologist of Vienna, who was connected with the Austrian expedition around the world of the Novara, from 1857 to 1860, died on the 18th of July, in his fifty-sixth year.

APPENDIX.

ART. XXI.—*On the United Metatarsal Bones of Ceratosaurus;* by Professor O. C. MARSH.

IN the April number of this Journal (vol. xxvii, p. 331), writer described a remarkable new Dinosaur, the type of genus *Ceratosaurus*, and of the family *Ceratosauridæ*. e skull, vertebræ, and pelvis were described and figured, t at that time little was known about the feet. More ently portions of these have been recovered from the same dividual, and they prove to be as remarkable as the other rts of the skeleton already made known.

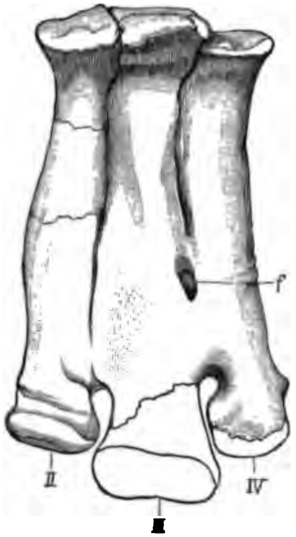
The most interesting feature in the extremities of this nosaur is seen in the metatarsal bones, which are completely kylosed, as were the bones of the pelvis. There are only ree metatarsal elements in each foot, the first and fifth ving apparently disappeared entirely. The three metatarsals maining, which are the second, third, and fourth, are oportionally shorter and more robust than in the other nown members of the order *Theropoda*, and, being firmly nited to each other, they furnish the basis for a very strong nd foot.

In figure 1, these coössified metatarsals of *Ceratosaurus* are presented, and for comparison the corresponding bone of a nguin is given in figure 2.

In comparing these two figures, it will be seen that the three etatarsal elements of the Dinosaur are quite as closely nited as those of the bird. To the anatomist familiar with e tarso-metatarsal bones of existing birds, the specimen presented in figure 1 will appear even more like this part in e typical birds than the one shown in figure 2.

The position of the foramen, as seen in figure 1, *f*, is especially characteristic of recent birds, and, as a whole, the hind foot of this Jurassic Dinosaur was evidently similar to that of a typical bird.

1.



2.

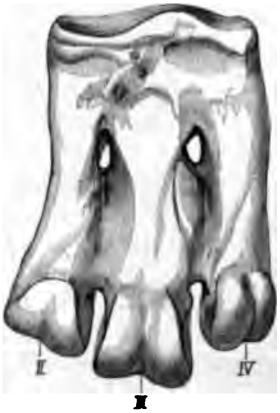


Figure 1 —United metatarsal bones of *Ceratosaurus nasicornis*, Marsh; left foot, front view. One-fourth natural size.

Figure 2.—United metatarsal bones of great Penguin (*Aptenodytes Pennantii*, G. R. Gr.); left foot, front view. Natural size.

All known adult birds, living and extinct, with possibly the single exception of *Archæopteryx*, have the tarsal bones firmly united, while all the *Dinosauria*, except *Ceratosaurus*, have these bones separate. The exception in each case brings the two classes near together at this point, and their close affinity has now been clearly demonstrated.

Yale College, New Haven, July 23d, 1884.

THE

MERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

RT. XXII.—*On the Amount of the Atmospheric Absorption;* by S. P. LANGLEY.

rom a communication made to the Nat. Academy of Sciences, in April, 1884.]

THE earth is surrounded by an absorbing atmosphere, and e never see the sun or the stars except through it.

When we wish to know what the absolute brightness of the n or of a star is, we must then first ask what the degree and ind of this absorption has been, and must add to the directly served quantities of light, the amount that the atmosphere has ken away. Accordingly, every one engaged in such researches ust determine in explicit or implicit terms for himself, or take n trust through another, the amount of the absorption, which ere is great unanimity in fixing at about 20 per cent of the hole (at the sea level.) Thus the earliest observations in the st century give the light absorption as 19 per cent. The very laborate ones by Seidel of Munich give 21 per cent, those by ritchard at Oxford, 21 per cent; the most recent by Mueller t Potsdam, 17 per cent; while the observations by Pouillet on e sun's heat give 18 to 24 per cent; and almost all of a great umber which could be cited, whether on light or heat, give bout 20 per cent. It has indeed been recognized of late years at the "light" rays are on the whole more absorbable than ose of "heat," and that, in particular, blue light is much ore so, but the difference between the mean coefficients of light" and "heat" as found by the usual methods is so small at we may here continue to speak of this "light" absorption 20 per cent as closely applicable (in common estimation) to at also. Thus, the very careful series of Ericsson on the sun's heat gives about 21 per cent. In fact, many thousands of observations by scores of observers, during the past and present century, seem to have determined this proportion with all the exactness of which it is capable.

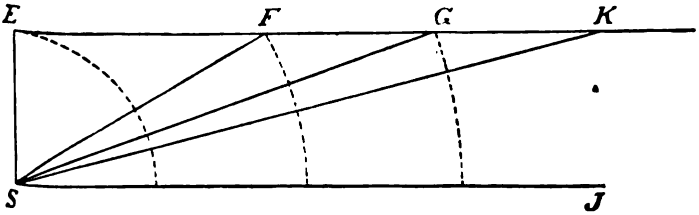
I have arrived at a result so wholly different, that, in the face of such authority, I almost hesitate to announce it; for I have been forced to the conclusion, that all these determinations are in error; and not in some small degree, but by a quantity probably at least equal to the total amount in question.

I hasten to say, that I do not dispute the general accuracy of the numerous skillful investigators of known repute who have made these determinations, but that I dissent from the method in almost universal use for reducing them, for since it is certain that none of these observers have been outside the atmosphere to see what the radiation really is; all of them, however skilled, must depend on inference to determine what it would be, if they could thus observe it. It is certain that nearly all have used a formula of which it seems capable of absolute demonstration that it is not only erroneous, but that its error always lies in one direction, so as to invariably make the calculated absorption too small, and it may be further shown with an evidence which seems little less than demonstrative, that the numerical value of the error is very large in relation to the quantities involved.

I have been led however, not by theoretical considerations alone, but by experimental investigation, (during the course of which I have observed both near the sea-level and at great altitudes), to the conclusion that the laws under which solar and stellar light and heat are absorbed by the atmosphere, are so complex that their complete comprehension is still beyond our power, but that we may at least now improve our present ways of studying them, for investigators have, however skillful in their observations, commonly ignored the complexity of the problem of their reduction, and, assuming that it is as simple as we could wish it to be, have proceeded to compute the result by such a formula as it would be most convenient for us, if nature would follow. Thus, owing to a natural tendency to accept as sufficient any scientific dogma which has respectable sponsors and which saves labor, the simple rule, established over a century ago by Bouguer, and consecrated by the use of Herschel, and Pouillet, to whom it embodied all the knowledge of their time, is commonly used by us to-day; though we may easily be convinced that it has ceased to express the facts known to ours.

To justify this language, let us consider what the problem appears to be, at first glance, and what the first suggestion is for solving it. If a beam of sunlight enters through a crevice in a dark room, the light is partly intercepted by the particles of dust or mist in the air, the apartment is visibly illuminated by the light laterally reflected or diffused from them, and the direct beam, having lost something by this process, is not so bright after it has crossed the room, as before. In common language, the direct light, to an observer in the path of the beam, has been partly "absorbed," and the problem is, to determine in what degree. If a certain portion of the light (suppose one-fifth) was thus scattered, the beam after it crossed the room would be but four-fifths as bright as when it entered it; and, if we were to trace the now diminished beam through a second apartment altogether like the other, it seems at first, reasonable to suppose that the same proportion (i. e. four-fifths of the remainder) would be transmitted there also, and that the light would be the same kind of light as before, and only diminished in amount (in the proportion $\frac{4}{5}\times\frac{4}{5}$.) The assumption originally made by Bouguer* and followed by Herschel and Pouillet, was that it was in this manner that the solar heat was absorbed by our atmosphere, and that by assuming such a simple progression the original heat could be calculated. (The relatively minute expenditure of energy in the actual warming of the air is of course to be included.)

Let us (to repeat Bouguer's reasoning) divide in imagination any homogeneous absorbing medium, into successive strata of identical thickness and chemical constitution.



Let A be a source of radiant heat or light, whose intensity is reduced by passage through the first stratum to (let us suppose) a fraction of the original represented by p, so that what was A becomes Ap. Then, since the second stratum is identical with the first in constitution and amount, and must (it is assumed), have an identical effect, it will, on Bouguer's hypothesis, transmit p of what enters it, and Ap^2 will emerge from the second, and so on, the fraction p transmitted by the unit of thickness (the "coefficient of transmission ") being evidently the common ratio of a geometrical progression, so that if the original heat be A, the amount of heat after passing through e strata will be Ap^e and the amount transmitted at any point will be proportional to the ordinate of a logarithmic curve.

To apply this to the estimate of the heat outside the atmosphere (i. e. before absorption), let SJ be a small portion of the earth's surface, and EK the upper surface of the atmosphere, which is here supposed to be of uniform density and constitution. (The effects of the actually unequal density of successive strata, can, it is assumed, be calculated and allowed for.) Let S be the observer's station, then ES would be the direction of a ray where the sun is in the zenith, and, to fix our ideas, let FS=2 ES; GS=3 ES; KS=4 ES, etc. The original heat A would become Ap after passing through one stratum (ES); and, according to what has been assumed, it would become (when the sun's zenith distance became ESF) Ap^2 after absorption by the two strata between F and S, Ap^3 after absorption by the three strata between G and S, etc. A, the original heat, and p the coefficient of transmission, are unknown; but if we make an observation of the heat actually reaching S along FS (let us call this heat m) and again later in the day along GS (calling this second observed quantity n) we have in the particular case supposed

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* Bouguer, "Traite de la lumière," Paris, 1760.

$$Ap^2=m \qquad Ap^3=n$$

whence A and p both become known. Designating the number of strata by e and the observed values (m or n) by t, we have then $Ap^e=t$; the exponential formula of Pouillet and later investigators. Its fundamental (and erroneous) assumption is, that the coefficient of transmission (p) is a constant.

It is no doubt true that a very sensible portion of the solar rays is scattered by an analogous process in our atmosphere; but we have in our present knowledge to consider that by whichever of its effects we note it, this radiation is not simple but complex. Thus, we must remember that heat, like light, is of different kinds. To use Melloni's illustration, radiant heat would to any eye that could '*see*' it, appear to be of totally different colors, and hence, it may be added, we ought no more to attribute to it a single rate of absorption with regard to any absorbing medium, than to assume that a blue and a red ray would pass through a red glass with equal facility. The statement of this fact, may perhaps seem superfluous to the reader, for it has long been in one sense well known. But in another and most important sense it is not well known, and it cannot be superfluous to recall its bearing on our present research, since it is the neglect to follow it into its consequences which has led to the error in question. Since then the solar energy, whether regarded in whole as "heat" or "chemical action," or in part as "light," is the sum of an infinite number of radiations, these may be conceivably influenced in an infinite diversity of ways by the different atmospheric constituents. In fact the larger particles rather reflect than diffuse the heat or light, and hence treat all wave-lengths nearly alike, or diminish the direct radiation by a nearly general absorption: minuter ones begin to t selectively, or on the whole more at one end of the spectrum an the other: smaller particles, whether of dust or faintest st, and smaller still, form a probably continuous sequence more and more selective action, down almost to the actual lecule, whose vibration is felt in the purely selective absorpn of some single ray. The effect of the action of the grosser st particles then, is to produce a general and comparatively lifferent "absorption" of all rays, after which the spectrum uld everywhere seem equally less bright and less hot. The ect of the molecular absorption, is to fill the spectrum with idences of the selective action in the form of dark telluric es, taking out some kinds of light and heat, and not others, that after absorption what remains is not only less in amount t *altered in kind.* Between these two extreme examples of sorption, we repeat, an unlimited number of others must ex; but we shall need here for simplicity to first treat the whole coming under one or the other of these two types, a procere already more accurate than the primitive one followed by ouguer, Herschel and Pouillet, but which we recognize as ill but a convention, which is imposed on us provisionally by e actual complexity of nature.

It will be seen now more clearly, that the whole primitive pross followed by Pouillet is an assumption, for it is simply taken r granted that the same proportion will be absorbed by one ke stratum as by another. On actually trying the experiment, owever, with media in the laboratory, Melloni long since oberved that like proportions were *not* absorbed by like strata; and he reason was found in the fact just noted, that radiant energy s not a single emanation, but the sum of an infinity of diverse nes, each with its own separate rate of absorption. It follows hat the coefficient of transmission is truly constant only in the ase of the absolutely homogeneous ray, which the ordinary hotometer or thermometer cannot in the least discriminate; nd which the finest linear thermopile or bolometer can but pproximately discern, and hence, that the original light of the tar, or heat of the sun, and the amount absorbed, can at best nly be found approximately. However familiar this principle ay be in some departments of physics, astronomers and meterologists have been slow in making this application to the resent case, but have continued to deduce the brightness of the tars, or the Solar Constant, from observations in which the adiation is either treated as absolutely homogeneous or in which s non-homogeneity is scarcely recognized as a factor of imporance.[*]

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[*] Exceptions to this remark are however to be made in favor of the very early ork of Principal Forbes (Royal Society's Philosophical Transactions, May, 1842), nd of the more recent labor of M. Crova (Academie des Sciences de Montpellier,

This neglect to make what seems so pertinent an application of Melloni's observation, even after it had been explained and extended (by Biot) will seem more explicable, when it is remembered that no direct means of measuring the absorption in even approximately homogeneous rays till very recently existed, and that a departure from the old formula, which ignores the difficulties, involves their recognition, and the devisal of new processes to meet them. Even if we, by the employment of such new processes, succeed in measuring the absorption in approximately homogeneous rays, the approximation is chiefly to homogeneity in wave-length, and not to uniformity of physical properties in consecutive wave-lengths, so that we are unable to represent the absorption as any continuous function of the latter. In other words, we may measure on separate narrow portions ($\Delta\lambda_1$, $\Delta\lambda_2$, etc.) of the spectrum and determine for each its apparent coefficient of transmission, (p_1, p_2, etc.) which is in each case some function of the wave-length, but we are not at liberty to write that the original energy of the heavenly body

$$A, = \int_{\lambda_n}^{\lambda_m} (\varphi\lambda)^{-\epsilon} d\lambda$$

since our $\varphi\lambda$ is really discontinuous, a remark the import of which will become more apparent in the sequel. For the present at least, we are at liberty only to divide the spectrum into a finite number of parts and to sum the results.

I have already stated elsewhere* that in neglecting the fact that the absorption is really selective, we not only commit an error, but an error that always lies in one way, so that any determination of the absorption we make by the ordinary and erroneous formula never errs by being too great, but is, so far as it depends on this formula, always, and invariably, too small. The demonstration may be put in an extremely simple form, but I am not aware that it has been elsewhere given, though it was indicated in the proceedings just cited.

Let us first suppose the radiation of the heavenly body to be really composed before absorption of two portions, A and B.

1876). See also the excellent little treatise "Actinometrie" by M. Radau. The use of two coefficients is proposed in this, as it has been before, but does not seem to have been followed by others, who like M. Violle, have subsequently (Annales de Chimie et de Physique, 1879) employed but a single coefficient of transmission. Still more lately, however, the importance of the consideration on which the writer here insists has been remarked on by Messrs. Lecher and Pernter, and perhaps by others. The employment of the method of Forbes, especially as modified and extended by Crova, appears to be the best means at the command of the observer with the actinometer or photometer. This method, however, is unfortunately very limited in its practical application, owing to the insufficiency of data thus obtainable, and it still gives a necessarily too small result, though a larger one than Pouillet's.

* Comptes Rendus de l'Acad. des Sc., xcii, 701, March 21, 1881.

Let A have a special coefficient of transmission (a), and B another, special to itself (b). Then, if we assume (still for considerations of convenience only) that each of these portions, is, separately considered, homogeneous, we may write down the results in the form of two geometrical progressions, thus:

TABLE 1.

Original radiation.	Ratio.	Radiation received after absorption by one stratum.	By two strata.	By three strata.	By four strata, etc.
A	a	Aa	Aa^2	Aa^3	Aa^4
B	b	Bb	Bb^2	Bb^3	Bb^4
A+B		$Aa+Bb$ $=(M)$	Aa^2+Bb^2 $=(N)$	Aa^3+Bb^3 $=(O)$	Aa^4+Bb^4 $=(P)$

Then will

$$\frac{Aa+Bb}{A+B} < \frac{Aa^2+Bb^2}{Aa+Bb} < \frac{Aa^3+Bb^3}{Aa^2+Bb^2} < \frac{Aa^4+Bb^4}{Aa^3+Bb^3} < \text{etc.}$$

$$\text{and } \frac{Aa^2+Bb^2}{Aa+Bb} < \left(\frac{Aa^3+Bb^3}{Aa+Bb}\right)^{\frac{1}{2}} < \left(\frac{Aa^4+Bb^4}{Aa+Bb}\right)^{\frac{1}{3}} < \text{etc.} \ldots$$

The fractions here are the coefficients of transmission, as deduced from observations at different zenith distances. They evidently differ, and (as will be shown) each is larger than the preceding.

In the above table $Aa+Bb$ is the sum of the two kinds of radiation as observed after absorption by one unit stratum (sec. $\zeta=1$) by the photometer, or actinometer; Aa^2+Bb^2 is the sum of the radiations observed after absorption by two strata (sec. $\zeta=2$) etc.; but we are here supposed to independently know the really dual constitution of the radiation, which the photometer or actinometer does not discern. According to the usual hypothesis, the coefficient of transmission, which is the quotient obtained by dividing the value after n absorptions by that after n-1 absorptions, or more generally that from the expression

$$\left(\frac{\text{Value after } n \text{ absorptions}}{\text{Value after } m \text{ absorptions}}\right)^{\frac{1}{n-m}}$$

is a constant. It is in fact not a constant, as we shall prove later; but we shall first show that, if we proceed upon the ordinary assumption, the value obtained for the original light of the star before absorption will in this case be too small. For, if we observe by a method which discriminates between the two radiations, we shall have, if we separately deduce the original lights from our observation of what remains after one and again after two absorptions, the true sum

$$A+B=\frac{(Aa)^2}{Aa^2}+\frac{(Bb)^2}{Bb^2}$$

while if we observe by the ordinary method, which makes no discrimination, we shall have the erroneous equation

$$A+B=\frac{(Aa+Bb)^2}{Aa^2+Bb^2}$$

which is algebraically less than the first, or correct value, for the expression

$$\frac{(Aa)^2}{Aa^2}+\frac{(Bb)^2}{Bb^2}>\frac{(Aa+Bb)^2}{Aa^2+Bb^2}$$

readily reduces to the known form

$$a^2+b^2>2ab.$$

Moreover since $a^2+b^2-2ab=(a-b)^2$, *the error increases with the difference between the coefficients.*

Now, in the general case, if we suppose the original radiation L to be composed before absorption, of any number of parts A_1, A_2, A_3, + . . . having respectively the coefficients of absorption a_1, a_2, a_3, + . . . the true value of L is given by a series of fractions which may be written in the form

$$L=\Sigma\frac{(Aa)^2}{Aa^2}=\Sigma A$$

whereas the value of the original energy by the customary formula would be

$$L_1=\frac{\Sigma\,(Aa)^2}{\Sigma\,Aa^2}$$

so that, all the quantities being positive, by a known theorem $L>L_1$, and for the same values of A_1, A_2, A_3, ... the inequality is greater, the greater the difference in the values of the coefficients a_1, a_2, a_3 . . .

But this is stating in other words that the true values, found by observing separate coefficients of transmission, are *always* greater than those found when we do not distinguish between the radiations of which the light (or heat) of the star or sun *is* composed, and also that the amount by which the true values are greater, increases with the difference between the coefficients.

We have stated above that the usual hypothesis makes the coefficient of transmission a constant. It will be seen from the above table, however, that it varies from one stratum to the next; that it is least when obtained by observations near the zenith; and that it *increases progressively as we approach the horizon.* For since a and b are each less than unity, each of the sums $Aa+Bb$, etc., in the above table is less than the preceding. It is also evident that their rate of diminution decreases as we approach the horizon, since

$$Aa^2 - Aa^3 > Aa^3 - Aa^4 \qquad Bb^2 - Bb^3 > Bb^3 - Bb^4.$$

Hence

$$(Aa^2 + Bb^2) - (Aa^3 + Bb^3) > (Aa^3 + Bb^3) - (Aa^4 + Bb^4).$$

Consequently the difference between the numerators of two successive ratios, such as

$$\frac{Aa^3 + Bb^3}{Aa^2 + Bb^2} < \frac{Aa^4 + Bb^4}{Aa^3 + Bb^3}$$

is less than that of their denominators. In other words, although both numerator and denominator decrease in successive ratios, the ratios themselves increase progressively, and a similar demonstration applies to the form

$$\frac{Aa^2 + Bb^2}{Aa + Bb} < \left(\frac{Aa^n + Bb^n}{Aa + Bb}\right)^{\frac{1}{n-1}}.$$

But these ratios are the coefficients of transmission in question.

Again, a simple inspection of the form of the expression,

$$Aa^2 - Aa^3 > Aa^3 - Aa^4 \qquad Bb^2 - Bb^3 > Bb^3 - Bb^4$$

shows that what is there demonstrated for two numbers and two coefficients A, a, and B, b, is true for any number, even infinite, which is the case we deal with in actual observation.

It is then universally true that when the numbers are positive, and a, b, c, d, ... proper fractions

$$\frac{Aa^{n+1} + Bb^{n+1} + Cc^{n+1} + Dd^{n+1} + \ldots\ldots}{Aa^{n} + Bb^{n} + Cc^{n} + Dd^{n} + \ldots\ldots} < \frac{Aa^{n+2} + Bb^{n+2} + Cc^{n+2} + Dd^{n+2} + \ldots\ldots}{Aa^{n+1} + Bb^{n+1} + Cc^{n+1} + Dd^{n+1} + \ldots\ldots}$$

and hence universally true, that when the separate coefficients of transmission are positive and less than unity (as is the case in Nature), the general coefficient of transmission in the customary exponential formula is,

(1) *never a constant*, and (as determined from the customary formula),

(2) *always too large*,

(3) *always larger and larger as we approach the horizon.*

(4) The original light or heat of the heavenly body as found by the photometric and actinometric processes, and the formulæ, in universal use, *is always too small*, a conclusion which we have just reached by another method.

The above demonstration does not tell us in how great a degree this coefficient is too large, and for aught we have here yet shown, the error may be practically negligible.

Since the method ordinarily employed demonstrably gives too small results, the burden of proof might seem to rest on those who still employ it, who might now with propriety be asked to show that the continued use of methods and formulæ, certainly in some degree inaccurate, does *not* lead to an error at least as great as the total absorption in question. This has never been done. There is a common assumption that if there were any considerable error, its results would become apparent in such numerous observations as have been made all over the world in stellar photometry and solar actinometry during this century, since in these observations of stellar magnitudes, for instance, two stars whose relative magnitudes are positively known, give results closely agreeing with the ordinary formula when one is near the zenith and the other near the horizon. At first this looks almost like evidence that there can be no great error in the determination of absolute magnitudes by the ordinary formula, and yet this apparent proof is demonstrably a fallacy It is certainly a specious one, but it is absolutely demonstrable that the error *might* be enormous—that the actual absorption might be, for instance, 50 per cent instead of 20, without this gross discrepancy being detected by our present modes of observation. As the present methods are known to give, as I have just said, values in substantial agreement (within three or four per cent) from independent observations made at very different altitudes of the sun or star, the proof of this last statement may well be demanded, and I proceed to give it.

(It is admitted that the original energy is divisible into an unlimited number of rays, each characterized by its own coefficient of transmission, and that these coefficients have values varying from zero to unity.) Let this original energy of the heavenly body be X, and let us denote as in table 1 the observed energy after one absorption by M, after two, by N, after three, by O, etc.

The assumption of those who admit the existence of an error but maintain that it is negligible, is that since we do know that $O:N=N:M$ very nearly, *therefore* $N:M=M:X$ very nearly, or in other words that if observation proves that $M=\frac{N^2}{O}$ within three or four per cent, we are entitled to assume that there is only a like small error in writing $X=\frac{M^2}{N}$.

We can make the fallacy of the preceding assumption most obvious by first considering a particular case. Let the original energy be divided into any number of parts A, B, C, etc., each with its own coefficient a, b, c, etc., so that

$$\begin{array}{l}
Aa+Bb+Cc+Dd+++Kk+Ll \text{ etc.}=M \\
Aa^2+Bb^2+Cc^2+Dd^2+++Kk^2+Ll^2 \text{ etc.}=N \\
Aa^3+Bb+Cc^3+Dd^3+++Kk^3+Ll^3 \text{ etc.}=O \\
\text{etc.,} \qquad \text{etc.,} \qquad \text{etc.}
\end{array}$$

have only to assume that *k*, *l*, etc., are sufficiently near) that K, L and all other rays affected with such coeffisensibly vanish before they reach the observer), to see e only quantities sensible to observation are those with ıly large coefficients as A, B, C, D, etc., so that now

$$\begin{aligned} Aa + Bb + Cc + Dd + \text{etc.} &= M \\ Aa^2 + Bb^2 + Cc^2 + Dd^2 + \text{etc.} &= N \\ Aa^3 + Bb^3 + Cc^3 + Dd^3 + \text{etc.} &= O \end{aligned}$$

;hese values M, N, O, etc., it is plain that we can never e the amount of the extinguished rays K, L, etc., since lo not enter into the observed values by any amount e at all.

to the rays A, B, C, D, etc., which remain, and to theirents, we may evidently assign any values consistent with ditions, which shall make the difference between $\frac{M}{N}$ and nall as we please, for in the equations

$$\frac{Bb + Cc + Dd + \text{etc.}}{Bb^2 + Cc^2 + Dd^2 + \text{etc.}} - \frac{Aa^2 + Bb^2 + Cc^2 + Dd^2 + \text{etc.}}{Aa^3 + Bb^3 + Cc^3 + Dd^3 + \text{etc.}} = R$$

ı always assign positive and real values to A, *a*, etc., ıat R may be as small as we desire.

R represents here the apparent error of observation as 1 from a comparison between "high and low stars." it follows that *however close the agreement may be observations on absorption, made at quite different alti- f the heavenly body, we have no right to infer that the f the final result is not indefinitely great.*

ıile the truth of the above proposition be admitted in tract, it is still urged that we do not, as a matter of fact, ason to suppose that so indefinitely large a part of the ays are quite extinguished ere they reach us, I would out that it is not in reality necessary to suppose the extreme case (*i. e.* that of a large part of the original ›n being wholly absorbed), which has been taken here make the nature of the argument more evident.

f we agree (as we certainly may) that a notable portion coefficients are near zero, and another notable portion ıt small fractions of unity, what we have just shown for eme case will also hold for the usual one, for it follows ıe previous demonstration that the greater the discrep- tween the coefficients, the more shall we underrate the sorption and the greater will be our error. To see what ıditions actually are, in inferring it from the ordinary ı, we must now consider more narrowly how this telluric absorption takes place. I have already spoken of the general, or non-selective absorption, whose extreme type is the scattering of light by large dust-particles in a sun-beam, and now proceed to consider the other typical extreme, which is that of purely selective absorption.

I have here some photographs* which I owe to the kindness of Professor Rowland of Baltimore, in which we have a portion of the spectrum near D, photographed when the sun was on the meridian, and a second photograph of the same limited portion at about half-past three in the afternoon, when the air-mass traversed was only about one-half greater.

Notice, nevertheless, the immense difference caused by the growth of telluric lines in this short interval. There is scarcely a hair's breadth of the plate, which they have not invaded. It is true the whole spectrum is not so densely crowded with them, as this region is, and yet, broadly speaking, we may say that almost the entire spectrum is visibly filled with telluric lines, in all but juxtaposition, just before sunset.

What is a telluric line? A very narrow, black and cold region, where the absorption has already done its full work, or which is at any rate so black and so cold, that it can grow very little blacker or colder. The extinction of the ray here is nearly absolute, or in other words, its coefficient of transmission is very small indeed. If we consider the same part of the spectrum at noon, we find that the region occupied by these lines must in reality be darker than if there were no absorbing air, even if the absorption has not progressed so far that the individual absorption lines are visible, or distinctly black. But in fact we do see parts of them distinctly black even at noon. Moreover, if we climb a mountain into the upper air, we find great numbers of these rays practically extinguished even there, long before they have reached the observer at sea level. In this way, I have myself observed numerous telluric lines quite black on Etna,† and even at greater altitudes, in the pure dry air of the Sierra Nevadas of California, so that there is much reason to believe that at the highest altitudes attainable by man, certain portions have already disappeared from the spectrum, and that we cannot correctly infer the original condition by any amount of observation on the different rates of absorption of what remains. Irradiation makes the telluric line appear narrower and weaker than it really is. Photography in this respect is probably a more trustworthy guide; and I think that those of us who are used to seeing the spectrum of a low sun, and who have gathered any impression of thinness and rarity of these lines, may correct our ideas with advantage, by the study of these admirable photographs, of which I will only observe, that when they were taken, the air-mass at noon was 1·09 and in the afternoon, 1·60, so that all this increase of telluric lines, came with a very little increment of the absorbing air, and is but a small part of what we should see nearer sunset. Evidently the noon spectrum must be less bright, not only for the telluric lines distinctly seen, but for those indistinctly seen individually, or latent only, and which come out as separate individual lines when the sun is lower. It results from what has just been said, then, that the part of the absorption due to telluric lines alone, is more considerable than is commonly thought, and that the coefficients of absorption and transmission, which have been obtained by various writers on actinometry and photometry, are really in general the mean coefficients obtained from the average of hundreds of these alternations (and necessarily too small), and yet more than this, that the smallest part included in the field of the experiment, whether the telluric lines are separately visible, or whether they are only latent there, is filled with alternations of transmission and absorption, and therefore, according to our previous demonstration, the mean result, even when obtained by a linear thermopile or bolometer, must still indicate too feeble an absorption. I speak now only of the strictly selective absorption, but I again remind the reader that there is also the partly selective and comparatively non selective absorption already mentioned, and that, practically, between the telluric line and the general absorption, we have every intermediate coefficient of transmission from unity to zero. The previous criticism applies then, though in a less degree, to the few investigations where two or three coefficients have been used, and even to investigations with the linear thermopile or bolometer, using numerous coefficients, among which I mean to include my own. I have done all I could to minimise the error by measuring on rays as nearly homogeneous as possible, that is, by measuring on parts of the spectrum so narrow, that they may be called, without exaggeration, linear, a name which we may certainly apply to a hair-like line $\frac{1}{2}$ of a millimeter in width, forming the working face of the linear bolometer; but even this strip, when laid down in a considerably dispersed spectrum, covers more than the distance between the D lines; and if we fix our attention on that well known region as a type, we see that this hair-like line itself covers in this narrow interval alone, at least a dozen alternations between brightness and almost total extinction, so that though in respect to wave-lengths we may be said to measure approximately homogeneous rays with a linear instrument, in respect to this local absorption, we do not. I am convinced that we do not know what this absorption really is in amount, but I think we can now begin to see somewhat of what it is in kind, and may be prepared to agree that the data in the annexed table (table II) may represent numerically the proportions of nature, with a certain approximation. In this table (II) we have certain numerical results consequent on the approximative hypothesis that the total heat in sun or star is divided into a certain finite number of parts, each one of which has its own rate of absorption.

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* Not given here.

† See also the important observations by Professor Smythe on Teneriffe.

Here the radiant energy before absorption is supposed to be divided into ten parts, A, B, C, ... J, each having its separate coefficient of transmission *a*, *b*, etc., an arrangement which may be taken to represent some sort of adumbration of the complexity of nature's problem, and the method of her work. It is given here only in illustration of the kind and degree of the errors induced by use of the usual formulas, and the demonstration already given in no way depends on these numerical values, whose exactness I do not need to maintain, since they are offered merely in justification of the previous assertion, that the absorption at any rate *may* be more than double what we think it (as in this specific case) without our having means of knowing of our error through our present formula.

It may, however, be incidentally observed that these values do typify the facts, with a certain approximation to the real values of nature, for they are obtained by approximate solution of equations of the form

$$Aa + Bb + Cc + Dd + Ee \text{ etc.} = M$$
$$Aa^2 + Bb^2 + Cc^2 + Dd^2 + Ee^2 \text{ etc.} = N$$
$$Aa^3 + Bb^3 + Cc^3 + Dd^3 + Ee^3 \text{ etc.} = O$$

where M, N, O, etc., do not differ widely from the results of actual observation. The conclusion in this specific case therefore seems fairly typical of that in the general one.

We have here supposed that the radiant energy from the sun or star before it enters our atmosphere is divided into ten equal parts, each of which in general suffers some different partial absorption. While no ray may be absolutely absorbed or wholly transmitted, a certain small part (represented in the spectrum by known telluric lines) is so nearly absorbed, that its coefficient in the first decimal place would be 0, and a certain more considerable portion, corresponding in a general sense to certain infra-red rays, has coefficients here undistinguishable from unity. Probably the greater part of the spectral energy however is intermediate between these two extreme types, and so our numerical values indicate.

The first column is the original intensity before absorption. (We have in this particular example for simplicity, supposed

$= B = C \dots\dots\dots\dots = J = 1$, though this condition is necessary. It will be observed, however, that under it in second column $Aa = a$, $Bb = b$, etc., so that the coefficients ransmission, the ratios of each geometric progression, are same in this particular column, as the intensity after ›rption.)

TABLE II.

I. nal intensity rdinarily nknown.) B, C, etc.	II. Observed intensity after one absorption. Aa, Bb, Cc, etc.	III. Observed intensity after two absorptions. Aa^2, Bb^3, Cc^2, etc.	IV. Observed intensity after three absorptions. Aa^3, Bb^3, Cc^3, etc.	V. Observed intensity after four absorptions. Aa^4, Bb^4, Cc^4, etc.
1	·01	·0001	·000	·0000
1	·1	·01	·001	·0001
1	·2	·04	·008	·0016
1	·6	·36	·216	·1296
1	·7	·49	·343	·2301
1	·7	·49	·343	·2301
1	·8	·64	·512	·4096
1	·9	·81	·729	·6561
1	·9	·81	·729	·6561
1	1·0	1·00	1·000	1·0000
10= B+etc. = X	5·9= $Aa+Bb+$etc. =M	4·65= Aa^2+Bb^2+etc. =N	3·881= Aa^3+Bb^3+etc. =O	3·3143= Aa^4+Bb^4+etc. =P

If we determine the coefficients of transmission from a com- rison of II and III, we have $\frac{N}{M}=\cdot 789$;

from II and IV, we have $\left(\frac{O}{N}\right)^{\frac{1}{2}}=\cdot 812$;

from II and V, we have $\left(\frac{P}{O}\right)^{\frac{1}{3}}=\cdot 825$

d the corresponding mean absorptions are

$$1-\frac{N}{M}=0\cdot 21,\quad 1-\left(\frac{O}{N}\right)^{\frac{1}{2}}=0\cdot 188,\quad 1-\left(\frac{P}{O}\right)^{\frac{1}{3}}=0\cdot 175.$$

› that all our observations at very different altitudes are in bstantial agreement in indicating an absorption of from 18 to per cent, while yet all our inferences from them are quite rong.

If we observed by some method which discriminated between e different radiations of which the heat or light is composed, should have from the observations in columns II and III

$$+B+C+\dots\dots J=\frac{(Aa)^2}{Aa^2}+\frac{(Bb)^2}{Bb^2}+\frac{(Cc)^2}{Cc^2}+\frac{\dots\dots(Jj)^2}{Jj^2}=$$

$$\frac{\cdot 01}{\cdot 0001}+\frac{\cdot 1}{\cdot 01}+\frac{\cdot 2}{\cdot 04}+\text{etc.}\dots\dots=10$$

(the true value) while the ordinary and erroneous method, which does not discriminate, gives

$$A+B+C+\ldots=\frac{(Aa+Bb+Cc+\ldots)^2}{Aa^2+Bb^2+Cc^2+\ldots}=\frac{(5.9)^2}{4.65}=7.5 \text{ nearly.}$$

We give the most favorable case for the observer, where (what is rarely or never actually possible), he begins his observation with the sun or star in the zenith, in a sky so changelessly serene that he may continue them up to a point where secant $\zeta=4$ (corresponding to column V), and where the altitude is less than 15°; and we here suppose ourselves to have a prior knowledge both of the actual amount of the light or heat before absorption, and of its composition, while he is assumed to attempt to deduce the prior amount by the usual formula, and from the usual observations, made in the gross by the photometer or actinometer.

The successive values of the absorption thus found by comparing a zenith observation with three successively lower altitudes, are 21 per cent, 19 per cent, 18 per cent. All agree much within the probable error of actual observation, as observers conversant with this matter will readily admit, and yet the true value is all the while

$$1-\frac{5.9}{10.0}, \text{ or 41 per cent.}$$

It will have been noticed in fact, that the determinations of this absorption-coefficient by various observers already cited, differ among themselves as much as these values do from each other, and if these conditions represent those of nature, the result must be in practice, that years of observation will be accordant in giving the wholly wrong absorption of from 19 to 22½ per cent, and that the actual minute systematic discrepancies pointed out by our theory, and which are significant of some error in the formula, would probably remain long undetected. While the observer, then, we admit, has strong apparent evidence from the close agreement of his observations, that if there be an error in his formula, it is practically negligible, yet this evidence according to our demonstration is fallacious, and the actual error, as appears from the numerical illustration, *may well exceed double the amount* in question, for the above values might be increased without imposing any conditions but such as it may be reasonably assumed are those of nature.

The writer believes the actual mean absorption of sun and star-light to be not improbably over 40 per cent, at the sea level; but were the stars alone in question, the fact would have but little importance, since their relative magnitudes (unless considerable color is present) remain nearly the same with the false hypothesis as with the true one, and it is with their relative magnitudes that the student of stellar photometry is chiefly concerned, for he desires to know their relative brightness at the zenith rather than their absolute brightness outside the atmosphere.

With the sun, however, it is otherwise, for here it is the absolute heat or light which is in question.

Accordingly, when we apply our above conclusions either to problems of solar physics or of meteorology, the result is of an altogether different importance. Almost all the phenomena of meteorology would become predictable if we knew how much heat reaches the soil, and how much, and in what altered kind, is returned to outer space. To solve these problems we must know how much is absorbed by our atmosphere; and there are further reasons, independent of those cited, for believing that this may be more than double what is commonly supposed.

It may be observed that the comparison of observations at the base and summit of a very high mountain will enable us to obtain much better determinations than the method of high and low sun observations, not only on account of the diminution of the absorbing air-mass, but because we thus avoid certain systematic differences between the atmospheric conditions at noon and evening (or morning) which introduce constant errors into the results, in addition to those already considered. From such observations I have been led independently of theory to conclude that the absorption is greater than is commonly supposed. But beside this method, which is in reach of but few, there is another at the command of all, the significance of whose results seems to have been hitherto overlooked.

If we are willing to agree that most of the solar heat is not absorbed by our air in the sense of being accumulated there (since this would heat the atmosphere to the condition of a glowing gas) we must, it seems to me, admit that it is mainly diffused toward and away from us by particles, so that nearly all we lose by selective absorption from the direct light and heat of the sun, we ought to find reflected or selectively diffused to us from the sky, or turned away from us to outer space.* I have been engaged in measuring the heat and light from the sky around the sun, and that from the whole sky apart from the sun. These measures are still incomplete, and I will only say that they seem to show not only that the average amount of blue light (to speak for the moment of blue light only) which is thus scattered from an ordinary pure and cloudless sky at the sea level, already represents a selective absorption of very much over 40 per cent of the original blue in the direct sunlight; but that also the *mean* diffusion is, though less than this, still probably over 40 per cent, and hence that to obtain the actual light of sun or star before absorption, we must probably add over 40 per cent to the observed value. To make the propriety of this last statement clear, it may be observed that if there were bright clouds in the sky, we should have (as we know by experience) more light from the clouds, than from an equal portion of the blue, but that in this case, our observing station would gain the added light at the expense of those portions of the earth which were in the clouds' shadow, and in this case, therefore, we should not be justified in adding the light we receive to the observed sunlight to obtain that before absorption. But with a uniform sky, it follows that every point on the horizon enjoys the same sunshine that we do, at our own station; and here it is evident that if the atmosphere were taken entirely away, the sun would grow brighter by all the light which the atmosphere now sends us, and, in fact, by more, since this atmosphere is scattering light not only toward us, but also to outer space.

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* See the investigation of Tyndall on the cause of the blue color of the sky, Proc. Roy. Soc., vol. xvii, p. 223. See also the theoretical investigations of Clausius, Poggendorf Annalen, vol. cxxix, p. 330, *et seq.*, and of Lord Rayleigh, London, Edinburgh and Dublin Phil. Mag., Feb., 1871, *et seq.*

Roughly speaking we may say, that we receive on the average at the sea level, as much light from the sky as we do from the sun itself; getting more light from the sun at midday than from the sky, but more in the morning and afternoon from the sky than from the sun. There is no reason to believe that any smaller proportion of star-light is diffused earthward, and this is independent of that which is diffused toward outer space.

All my own investigations, whether through observations at the sea level or at an altitude of nearly 15,000 feet, lead me to believe it probable that the mean absorption of light (and of heat also) by our atmosphere is *at least double* that which is customarily estimated, and also to conclude that fine dust particles, both near the surface and at a great altitude, play a more important part in this absorption, both general and selective, than has been heretofore supposed. I hope soon to make public the result of an investigation into the composite character of the radiation, as an indication of what the sky has selectively borrowed from the direct solar rays.

ART. XXIII.—*Tornadoes*; by HENRY A. HAZEN.

THE true tornado," says R. H. Scott, "occurs off the west t of Africa and is identical with the arched squall of other rs." This restrictive definition of a tornado is not accepted rally in the United States, where it is applied to an intense, ingly local, outburst, ordinarily preceded by a funnel-ed cloud, having a rapid rotation and a more or less slow nd-down movement. The better designation would unbtedly be "whirlwind," but the term tornado has become so understood that it hardly seems wise to attempt a change. he importance of a proper study and a good knowledge of forces, which underlie the formation of a tornado, will be y recognized when we consider the enormous loss of life property that is annually occurring in the west and south. the western States become more thickly settled year by year, manifest that this loss of life will become greater unless ns for individual safety are provided in cellars and dug-outs lready recommended, or some more general means be emred for destroying or diminishing the force of the storm as proaches a large city. Such an idea may seem chimerical; if Franklin in the eighteenth century devised so simple and tive a means as the lightning rod for protecting buildings n lightning, surely the genius of the nineteenth century may rmine some means of mitigating, if not of wholly avoid- the evils under consideration. The devastation of large ges and the great terror induced at the possible approach tornado in a heavy dark cloud are sufficient reasons for the est study of these phenomena.

t is the object of this paper, first, to set forth some of the nary theories that are advanced for explaining the origin development of these outbursts; secondly, to show some of seeming difficulties in these theories; and thirdly, to point out w of the characteristics of these outbursts and to attempt to w lines of investigation upon which a further advance may be le toward a true knowledge of the forces underlying them.

nfortunately, their origin is involved in much obscurity, in part to a lack of observation of the conditions immeely preceding the sudden and destructive manifestations. following quotations from authorities will suffice to show e of the views at present entertained. One writer says: ne inward rush of winds toward a depressed center is the se of our thunder-storms, which are only infant cyclones and adoes. The whole country for 500 miles square from the souri to the Ohio valley is covered with a mass of warm moist air flowing northward. At numerous spots in this region this acquires an upward motion, thereby giving rise to local upward currents of air which cool rapidly as they rise. The cooling is a mechanical result of the expansion of the rising air and very soon a temperature is reached low enough to condense clouds from the hitherto invisible moisture. With the formation of clouds, the tendency to rise increases, so that in fact an upward suction is experienced under the cloud and more air is drawn in from all sides to feed this suction."

"Whatever causes a sudden uprush of moist air contributes to the formation of the cloud or the tornado. Hills or low mountains are very effective. But it is equally important to consider the cool dry air that flows from the north toward a low center and becomes a west wind as it turns around the low, runs into the mass of warm moist air coming from the south, and being denser, underruns and lifts up this warm air and is in many cases more effective than a mountain in starting the formation of a cloud and local storm."

Another writer gives a theory directly the opposite of this last and says: "Suppose a mass of warm, moist southerly wind has pushed itself below a colder northwesterly stratum. The warm wind, feeling about for a point of escape through its cold cover, soon makes or finds a vent where it can drain away upward, and then the entire warm mass even a mile or more in diameter and often more than one thousand feet in thickness, begins a rotary motion, rises at the center and passes away."

It is probable that theories upon the effect of the sun's heat upon the lower atmosphere have been at fault. It has been assumed that "this heat is developed in certain central portions of greatest heat." It is ordinarily considered also that the heat at the earth's surface is greatly increased and causes masses of heated air to rise to great heights. We cannot determine precisely the area uniformly heated by the sun during the hottest part of the day; however the temperature is well nigh at a maximum for at least an hour. This would give a circle of heated air over one thousand miles in diameter, which, if inland and at sea-level, would be heated with nearly equal intensity on clear calm days. Experiment shows that, while the earth's surface in sunshine becomes very hot, yet this heat does not extend to more than two or three inches in the atmosphere. At six inches the temperature is frequently from thirty to forty degrees less than at the surface, and from this point it diminishes not more than one half a degree in six feet, showing that there is no appreciable rising of heated air from the earth's surface.

The effect of the sun's heat may be considered as follows: the stratum of air nearest the earth will first be heated and entle convection currents set in motion, these will heat the ext stratum, and so on.

This is the explanation given by Prof. Hann of Vienna, who uthermore considers the formation of cumulus cloud in summer o be due to the action of vapor immediately at a height where he dewpoint is reached, but that no great interchange of air rom the lower to the upper atmosphere will take place from he action of heat alone.

Again, the evaporation and condensation of moisture are dvanced as important factors; it is stated for example: "Of reat importance is the action of vapor, as a great storehouse of olar energy, required in the process of its evaporation, generlly known as 'latent heat,'" and "condensation is attended with the production of just as much heat energy as was lost in he process of evaporation." Admitting for a moment that a warm vapor-laden current of air has found its way to some height above the earth, where is the evidence that a condensation will produce any more forcible effect than would have been noted in evaporation? If the process of evaporation goes on by insensible degrees, why may not the converse process of condensation take place in the same way? It would seem a hasty conclusion that a mass of vapor can be cooled and condensed so much more rapidly than it can be evaporated. Either process requires time and certainly that of cooling a large mass of air can only be accomplished slowly. That a rapid upward rush and consequent expansion would cool the air is evident, but it is by no means certain that there is this uprush, and again that the cooling would produce any sudden display of force. The fact that efforts at a computation of the probable liberation of energy arising from such action have given most diverse results, with even an absolute denial of any sudden release of energy, shows that such an hypothesis must be accepted with caution and should be supported by indubitable practical tests.

The theory that tornadoes occur where there are great contrasts of temperature in warm southerly and cooler northerly winds is not supported by the facts. This theory is partly based on the assumption that tornado action occurs near the center of a low area. It is admitted that immediately to the north and south of a storm center there are strong contrasts of temperature and there is a partial meeting of warm and cool winds, but there are no tornadoes at or even near that point.

Let us take a map of any region having upon it, very near the time of the tornado, lines of equal pressure and temperature and directions of the wind. There will invariably be upon it a storm-center. Through the center of this draw a line from southwest to northeast and we shall find on the northwest side low temperature and cold and dry northwest winds, due to an advancing high area. On the southeast side, however, the air is laden with moisture and is hot, there are frequent rains, and well nigh uniform south and southeast winds. On the southeast side also the isotherms are much farther apart than on the northwest side. If now we project the tornado tracks upon the map we shall find them in the region to the southeast, and generally hundreds of miles from the storm-center, where there are no northerly winds. A critical study of tornado tracks upon a weather map will develop these points in nearly every instance. Frequently there are in the tornado region higher temperatures in the north than in the south, and very seldom will there be a lowering of temperature from south to north any greater than the constant difference due to the difference in latitude.

Again, there seems to be a disposition to advance some general and sweeping theories about cold or hot winds underrunning hot or cold winds, etc. It may be said that, in a condition of equilibrium, the cooler air must flow beneath and, at all times there would be a more or less insensible diffusion of the two masses. It would seem difficult to account in this way for the definite formation of a tornado and its onward advance dipping here and there sometimes even across a state.

In seeking for a probable solution of the problem, and in testing the assumptions made, we have to-day a powerful adjunct in the weather map showing at any hour of the day the precise meteorological conditions existing over the region of tornado action. Such maps for three nearly equidistant hours of the day have been published by the U. S. Weather Bureau from 1872 to 1880. In order to ascertain the prominent facts connecting tornado action with storm centers there have been selected for this paper forty-one of the tornadoes described in Sergeant (now Lieut.) Finley's paper, "Characteristics of 600 tornadoes," also published by the Weather Bureau. Before the tracks were projected upon the maps, every tornado having special destructive action and at the same time a fairly well determined note of time, was tabulated and of these none were left out in the final result. Tornadoes between September, 1872, and September, 1879, have alone been considered.

TABLE.

Place.	Lat.	Long.	Date.	Hour.	Distance (miles) to and direction from low center			Temperature falls 10° in miles.	Winds near tornado.	Distance to nearest N. wind.	Pressure at low center.
Charlotte, N. C.	35·2°	80·8°	Sept. 8, '72,	5 p. m.	650	S.E.	135°	500	S. & S.E.	650	29"·76
Keokuk & Washington Co's, Ia.	41·3*	92·0*	May 22, '73,	2.15 p. m.	440	S.E.	135	200	S. & S E.	370	29·28
Cloud Co., Kans.	39·6	97·7	June 29, '73,	3 p. m.	480	S.S.E.	158	520	S. to E.	520	29·60
Cairo, Ills.	37·0	89·2	Mar. 18, '74,	4 a. m.	370	E.S.E.	112	210	S. & S.E.	260	29·76
DeSoto Co., La.	32·0	93·6	Apr. 7, '74,	4 p. m.	260	E.S.E.	112	140	S.E.	220	29·70
Butler Co., Kans.	37·8	96·9	June 22, '74,	p. m.	660	S.S.E.	158	400	S. & S.E.	none†	29·44
Troy, N. Y.	42·7	73·6	Aug. 2, '74,	p. m.	580	S.S.W.	202	260	N. & N.W.	....	29·55
Dixon, Ills.	41·8	89·5	Aug. 10, '74,	p. m.	620	S.E.	135	200	S.W. to S.E.	none†	29·33
Montevallo, Ala.	33·1	86·9	Nov. 22, '74,	p. m.	490	S.E.	135	130	S.	670	29·04
Fulton, Miss.	34·2	88·3	May 1, '75,	p. m.	600	S.S.W.	202	120	N.W.	....	29·10
St. Joseph Co., Ind.	41·6	86·3	June 1, '75,	p. m.	610	S.E.	135	150	S. to E.	none†	29·31
Quincy, Ills.	39·9	91·4	June 14, '75,	p. m.	540	E.S.E.	112	110	S.W. to S.E.	350	29·41
Omaha, Nebr.	41·3	95·9	June 17, '75,	p. m.	270	S.E.	135	160	N.E.	....	29·60
West Point, N. Y.	41·3	74·0	July 13, '75,	7.10 p. m.	420	S.	180	150	S.W.	390	29·54
Salem Co., N. J.	39·5	75·3	July 29, '75,	3 p. m.	550	S.E.	135	100	S.W. & S.	290	29·72
Lomonauk, Ills.	41·6	88·7	Aug. 5, '75,	7.20 p. m.	210	S.E.	135	390	S. & S.W.	410	29·50
Milford, Pa.	41·3	74·8	Oct. 30, '75,	p. m.	350	S.E.	135	270	S. & S.W.	800	29·53
Chicago, Ills.	41·9	87·6	Apr. 26, '76,	5.10 p. m.	780	S.E.	135	210	S. & S.W.	none†	29·41
Carbondale, St. Clair Co., Ills.	37·8	89·2	May 6, '76,	9.30 p. m.	360	S.S.E.	158	240	S. & S.E.	200	29·41
Saline Co., Kans.	38·8	97·7	June 6, '76,	3.30 p. m.	480	S.S.E.	158	400	S.W. to S.E.	600	29·45

* Lat. and long. of center. † No north wind.

TABLE—CONTINUED.

Place.	Lat.	Long.	Date.	Hour.	Distance (miles) to and direction from low center			Temperature falls 10° in miles.	Winds near tornado.	Distance to nearest N. wind.	Pressure at low center.
Washington Co., N. Y.	43.2°	73·2°	May 18, '77,	1.30 p. m.	220	S.S.W.	202°	200	S. & S.W.	400	29·59
Memphis, Tenn.	35·1	90·0	June 17, '77,	7 p. m.	1040	S.E.	135	1000	S. & S.E.	650	29·28
Elkhart, Ind.	41·7	86·0	July 2, '77,	4.30 p. m.	1030	S.E.	135	200	S. & S.E.	580	29·58
Council Bluffs, Ia.	41·3	95·6	Aug. 6, '77,	2.30 p. m	520	S.S.E.	158	580	S. & S.E.	190	29·75
Fayetteville, N. C.	35·0	78·9	Feb. 8, '78,	7 a. m.	420	S.E.	135	420	S. & S.W.	430	29·30
Cairo, Ills.	57·0	89·2	Ap. 23, '78,	4.10 a. m.	400	S.S.E.	158	240	S.E.	350	29·43
Carolina Landing, Miss.	33·0	91·1	May 18, '78,	p. m.	720	S.E.	135	120	S.	490	29·28
Barrington, Ills.	42·2	88·1	May 23, '78,	6 p. m.	600	S.E.	135	130	S.W. to S.E.	340	29·32
Cash Co., Mo.	38·6	94·3	July 16, '78,	2 p. m.	420	S.	180	700	S.	350	29·54
South Hartford, N. Y.	43·3	73·2	July 26, '78,	5.30 p. m.	290	N.E.	45	90	S. & S.W.	270	29·29
Wallingford, Conn.	41·5	72·9	Aug. 9, '78,	6 p. m.	480	S.	180	150	S. & S.W.	300	29·40
Near Dover Mines, Va.	37·7	77·9	Sept. 12, '78,	4 p. m.	300	N.E.	45	160	E. & S.E.	300	29·48
Monticello, Jones Co., Ia.	42·2	91·2	Oct. 8, '78,	5.30 p. m.	320	E.N.E.	68	90	S. & S.W.	260	29·54
Collinsville, Ills.	38·7	90·0	Apr. 14, '79,	2.45 p. m.	160	S.S.W.	202	100	N. & N.E.	....	29·50
Dallas, Tex.	32·8	96·8	Apr. 15, '79,	2 p. m.	240	S.E.	135	100	E. & N.E.	....	29·34
Walterboro, S. C.	32·9	80·7	Apr. 16, '79,	3.45 p. m.	320	S.E.	135	210	S. & S.E.	420	29·47
Barnard, Mo.	40·2	94·8	May 29, '79,	3.30 p. m.	420	S.	180	300	S.W. & S.	600	29·29
Lees Summit, Mo.	38·9	94·3	May 30, '79,	5.30 p. m.	260	E.	90	240	S.E. & S.	330	29·40
Delphos, Kans.	39·3	97·8	May 30, '79,	4 p. m.	60	E.N.E.	68	150	N. & N.W.	....	29·40
Erie Co., O.	41·4	82·7	July 11, '79,	3 p. m.	230	S.W.	225	300	S. & S.W.	300	29·46
Sandy Spring, Ind.	39·2	77·0	Sept. 3, '79,	6 p. m.	420	S.E.	135	270	S. & S.W.	510	29·33
Means	....	....	....	....	453	S. 39° E.	141	259	....	....	29·45

n this table, column six gives the distance in statute miles he storm-center; the next two columns contain the direction he tornado from "low," the numbers indicate the number degrees from the north counting by east. Column nine ws the approximate distance between isotherms ten degrees rt, or the distance giving a temperature fall of ten degrees. s column is presented here as only a rough approximation; as found necessary frequently to take the line of measure-ıt at right angles to the line toward "low," and the meas-nents are vitiated by great irregularities in the conformation he isotherms. Column ten contains the general course of winds in a large region surrounding the tornado. Column en gives, as nearly as possible, the distance to the nearest th wind; this was seldom measured in the direction of w;" if it had been, the distances would have been much ıter. The last column contains the lowest pressure at the ter. This table brings out many most interesting facts and its careful study.

t has been assumed that a definite relation exists between low," and the place of tornado action. Certain it is that no ensive tornado action ever takes place without the presence "low" of rather marked intensity. The probable influence high areas" is for the present neglected.

general average of this table gives the mean distance from w" 453 miles; mean direction, S. 39° E.; mean temperature ten degrees in 259 miles. The winds are almost uniform-rom the south and southeast, and if from any other rter, all are from that direction. The distances to the est north wind are variable, in many instances there were north winds on the map near the "low" or the tornado; mean distance in thirty-one cases was 407 miles.

Ve may conclude then, first, that in the region of tornado on there is no upward rush such as is supposed to take e at a low center; secondly, that the winds are uniform and e is no meeting of cool northerly with warm southerly ezes; thirdly, that there are no contrasts of temperature, fall of ten degrees in 259 miles being no more than would expected from the influence of latitude.

Another most important point is the existence of extensive l and thunder storms in the neighborhood of the tornado, ich would seem to show an intimate relation between the .

t has been commonly accepted that thunder-storms are local nomena, and that they are caused by heated air rising on m and sultry days and condensing its moisture in the upper ons. The facts, however, seem to show a much more par-lar cause. Take a very recent instance, the earliest extended thunder-storm of this year in the eastern United States. This occurred February 14, 1884, and was first noted at Augusta, Ga., early in the morning. It appeared at Lynchburg, Va., at 4 A. M., and at Variety Mills, Va., about the same hour, where it seemed to come from southwest and passed off to east-northeast. It passed over Washington, D. C. from west-southwest at 6.25 A. M. toward east-northeast. It was noted at Haverford College, Pa., and at New Castle, Del., at 8.30 A. M. These times (about some of which there is a little uncertainty) give the following velocity: Lynchburg to Washington, about sixty-two miles per hour; Washington to Haverford College, the same. The velocity across Washington, as determined by counting the seconds between the flash of lightning and the thunder, on the west as it came up and on the east as it passed off, was a little less than a mile a minute.

It may not be that one and the same storm passed across this whole region, though the evidence favors that supposition. One thing is certain, namely, that the meteorological conditions were suited to just such a development of thunder-storms over a large extent of country. It seems probable that they could not have been caused by the rising of moist heated air in a single locality. It is believed that no thunder storm can occur without a storm-center or disturbed region existing somewhat near it. This center may not make itself known by distinct bendings of isobars, but it can be easily recognized by the presence of cloudy weather and rainfall, with more or less incurving of the winds. An attempt has been made to divide thunder-storms into two classes—first, those caused in the presence of a low center of pressure, and, second, those due to the sun's heat. It may be admitted that the sun's direct heat is an important factor in the formation of summer thunder-storms, but this only acts in conjunction with the disturbed region which is invariably present.

If, now, such a thunder-storm action is general, and is dependent upon the presence of a storm-center, may we not hope by careful observation at short intervals of time and space, in the region over which the tornado action is expected to occur, to obtain a sounder basis of fact to reason upon than we now have?

One step further we may venture. If we can correlate thunder-storms and storm-centers, may we not expect to obtain by a critical study of the former some evidence of the forces acting in producing the latter? By such critical study we ought to be able to obtain answers to the following, among the questions relating to tornadoes:

At what distances and in what directions do they lie from the low center? How are they distributed with respect to thunder-storms? How are they connected with each other and what is their movement? What wind directions prevail? What is the distribution of temperature? Is their relation to storm-centers an invariable one? What is the character and distribution of hail storms? and so on. As a partial answer to the last question, observation seems to establish a rule that hail storms occur only in immediate proximity to storm-centers of considerable energy.

In order to be able to predict violent local storms and tornadoes we can accomplish much, as has just been suggested, by a study of a map containing the weather conditions over a large region.

Some of the signs of probable tornado action may be enumerated, in conclusion, as follows:

First—There must be a storm-center fairly well marked, though this may be 600 or 700 miles away. Tornadoes almost invariably occur to the south and southeast of this point.

Second—It is believed that the temperatures in the above region should be above the mean. Great contrasts of temperature are not necessary, and if, in connection with these, an area of high pressure is found to the northwest or west, no tornado will ordinarily occur.

Third—In general the air should be moist.

Fourth—As extended thunder-storm action is an invariable accompaniment of a tornado, it is believed that these may give some indications of more severe action. It is not thought that the above will prove an infallible guide, but ordinarily no tornado will occur unless the above conditions precede it.

Prof. Tait of Edinburgh has recently published an article on the origin of atmospheric electricity, in which he takes grounds similar to those of certain French savants, namely, that as yet we know little or nothing of the origin of this manifestation of electricity. It would seem that J. Allan Broun's theory that it is due to the direct influence of the sun's electricity upon the moisture of the air, or possibly to the indirect effect from the sun's heat is more satisfactory than the multifarious theories of friction, evaporation, condensation, etc. However this may be, it seems that the present theories on the origin of tornadoes are no more satisfactory than those on the origin of atmospheric electricity which are abandoned by Professor Tait. Certainly as all theories in regard to lightning have proved inadequate upon actual tests, so it should be insisted upon that no mere paper theory of tornado action can be accepted.

ART. XXIV.—*On the Absorption of Radiant Heat by Carbon Dioxide*; by J. E. KEELER.

AMONG the gaseous bodies whose power of absorbing radiant heat has engaged the attention of physicists, one of the greatest interest is carbon dioxide (CO_2, commonly called carbonic acid gas), since as a constituent of our atmosphere, its action has an immediate bearing upon matters whose importance to us is evident. It would seem at first sight as if the determination of the absorptive power of a gas were a matter of no great difficulty; yet this is so far from being the case that most conflicting results, especially in regard to the absorption of water vapor, have been reached by different investigators, the discussion between Tyndall and Magnus on this subject being well known. Quite recently the question has been revived, "In which of the gases composing the atmosphere does the power of absorbing the sun's rays lie?" And, indeed, when we consider that, according to measurements made by different observers at different times and places, the action of *any one* of the principal constituents of the atmosphere is sufficient to account for this absorption, it can hardly as yet be regarded as settled. That carbon dioxide has a remarkable power of absorbing radiant heat has long been known, and within the last few years, methods of analysis based upon this property have been invented.

The usual course pursued in investigating the subject is to allow radiant heat to pass through a stratum of gas of given thickness, and measure the amount stopped by it by comparing the indication of a radiometric apparatus placed opposite the source of heat before and after the interposition of the gas. In this way (considering the more recent experiments), E. Lecher and J. Pernter,* using as a radiant source a metal plate heated to 100° C. by steam and a gas stratum 31^{cm} thick, found that whereas neither dry nor moist air produced any absorption whatever, the action of carbon dioxide was very marked; from which they concluded that the absorption of the air cannot be ascribed to aqueous vapor which it contains, but must be attributed to carbon dioxide, which, according to their measurements, exists there in sufficient quantity to produce the absorption of the sun's rays indicated by the actinometric observations of Violle. Upon this conclusion Dr. Lecher† based a method for determining the percentage of CO_2 in the atmosphere, which he afterwards tested by observations upon the Alps. The method consists, in brief, in measuring the intensity of the sun's rays at different hours of the day, before and after passing through a tube of variable length filled with CO_2, the final result being given as the number of meters of pure CO_2 at the ordinary atmospheric pressure through which the sun's rays if vertical would pass in reaching the earth, the ratio of this to the depth of the homogeneous atmosphere giving at once the percentage of CO_2 required. It was to test the validity of this method, (which however is of little practical value, since it is only applicable in regions where the purity and constancy of the sky is quite exceptional,) and in the hope of contributing something toward the solution of the broader question first stated, that, while working in the laboratory of Professor von Helmholtz at Berlin during the winter of 1883, I devised and constructed the apparatus presently to be described. In the mean time it is well to examine the physical grounds which render the correctness of the method a matter of greater or less probability.

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* Wied. Annalen, xii, p. 180. † Wied. Annalen, xii, p. 466.

In the first place it is evident that it is of fundamental importance for its success that the remaining constituents of the air should contribute nothing to the absorption produced by the CO_2 itself, and it is not difficult to show that the evidence afforded by the experiments above quoted is insufficient to warrant the conclusion that this is the case. Since the absorption of the whole depth of atmosphere above us, equivalent to 8 kilometers at the surface pressure, is but moderate (it is not necessary here to be very precise), it is evident that that produced by the length of a column such as we are able to make use of in our laboratories must be very small indeed, so small that we could hardly hope for success in detecting it by the usual direct method, the limits of error of our apparatus being much larger than the quantity to be detected, and this even in view of the fact that the absorption in the first layers of a gas is greater than in the subsequent ones. In the case of CO_2 however, we have a very different state of things. Here we can employ within reasonable limits an amount of gas equal to or comparable with that traversed by the sun's rays before reaching our position on the earth, and may expect to produce as great an effect.

The experiments of Dr. Heinrich Heine* are much more conclusive. By measuring with a delicate form of manometer the increase of pressure of the enclosed gas due to warming by the absorbed radiant heat from a Bunsen burner, he found that while perfectly dry pure air produced no change whatever, the admixture of ·025 per cent of CO_2 produced a readily measurable increase, so that he was able to make very accurate analyses of the air by comparing its effect (after drying) with that of mixtures of known proportions. He did not however experiment on the absorption of air containing aqueous vapor or other gases.

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* Ueber die Absorption der Wärme durch Gase, und eine darauf beruhende Methode zur Bestimmung des Kohlensäuregehaltes der atmosphärischen Luft. Giessen, 1882.

Further, the *character* of the absorption of CO_2 must agree with that of the air if this gas is the seat of the absorptive power of the latter, and this gives us an independent means of decision. The absorption of a substance which permits the passage of radiant energy will exhibit peculiarities of which the following constitute the most marked cases. It may be strongly selective, i. e. confined to certain definite wave-lengths, by which lines would be produced in the continuous spectrum of a luminous source whose rays had passed through the substance; it may affect strongly rays differing but little in wave-length, producing broad bands in the spectrum; or it may extend over many wave-lengths, affecting each but little more or less than the next in succession, by which no perceptible lines or bands would be produced, although the intensity of the spectrum would be weakened within wide and indefinite limits. The latter has been shown by Professor Langley* to be the case with the atmosphere, and a very important part of this general selective absorption is in the visible part of the spectrum, increasing in amount with decreasing wave-length until it becomes very powerful in the violet and ultra violet. Indeed, even without the table of coefficients of absorption furnished by Professor Langley, the difference in the appearance of the sun at noonday and at sunset suffices to show that a very considerable part of the action of the atmosphere is exercised upon the visible solar rays. Since sharp lines caused by water vapor are found in the spectrum (representing however in themselves a very small amount of energy) the total atmospheric absorption is a complication of at least two of the above classes.

Further, the labors of the same investigator show that the true value of the solar constant is considerably greater than that deduced by ordinary actinometric methods, so that there would remain a certain amount of absorption unaccounted for by the action of carbon dioxide, assuming the latter to have been correctly measured; finally, analyses have shown that the percentage of CO_2 in the air is tolerably constant in all parts of the earth, whereas the absorbing power of the atmosphere varies greatly.

The apparatus which I made for investigating the absorption of CO_2 was originally intended to be used in connection with a Rowland grating, so as to test the absorption of nearly homogeneous rays; but, owing to the limited amount of time at my disposal after it was completed, I was obliged to content myself with the use of artificial sources of heat, which, although far from furnishing homogeneous rays, differed so widely in character that the results obtained seem to me to be sufficiently definite to indicate the true character of the absorption exercised by carbon dioxide on the rays of the sun.

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* This Journal, xxv, March, 1883.

The tube containing the CO_2 in this apparatus was 18^{cm} in diameter and 1·7 meters long, made of tin-plate, and open at both ends. It was placed vertically on a low tripod stand provided with foot screws, the lower end dipping into a shallow annular trough filled with quicksilver, by which it was completely closed. Concentric with the trough, and likewise supported by the stand, was a silvered glass concave mirror of one meter focal length and 16^{cm} in diameter, forming as it were the bottom of the tube when the latter was in place. By this arrangement the tube could be readily removed, while when in place it was stopped in a perfectly air-tight manner at the lower end, and the direction of the axis of the mirror could be adjusted by the foot screws without any motion being communicated to the tube. The upper end was left open, and reached nearly to a wide flat board, firmly supported in a horizontal position by a suitable stand or scaffold, from which projected arms to steady and hold the upper end of the tube. In this board, perpendicularly above the center of the mirror, was a hole, much smaller than the tube itself, over which was a combination of two rectangular plane mirrors, likewise of silvered glass, joined at right angles like a letter V, with the lower angle over the middle of the hole and the reflecting surfaces facing outward, so that each made an angle of 45° with the vertical. The line joining their centers was therefore horizontal, and was adjusted to a height of 6^{cm} above the upper surface of the board. In front of one of these mirrors was a slit, consisting of a hole 1^{cm} square in a copper plate faced on the side next the mirror with pasteboard. Directly opposite this, in front of the other mirror, and at the same height, was a similar although smaller aperture exposing the central strips of a bolometer, which was held by a sliding carriage, so that its distance from the mirror could be altered at pleasure. If then a source of light was placed in front of the slit, the rays passing through fell first upon the nearer inclined mirror and were reflected down through the tube upon the large concave speculum, thence converging back through the tube upon the second inclined mirror, and brought to a focus in front of it, forming an image of the same size and at the same height above the board, as the slit, but lying on the opposite side of the two mirrors, so that the bolometer aperture could be brought into the image by sliding the movable carriage along its ways. Between the slit and its image the rays had to pass through a distance equal to four times the focal length of the concave mirror or 4 meters, 3·4 meters of the distance being traversed within the tube. To facilitate the adjustments the slit was made movable in its own plane through a small distance in every direction, and all possibility of direct rays from it reaching the image was removed by interposing a series of screens.

The bolometer used, for which I am indebted to the kindness of Prof. Langley, had a resistance on each side of about 30 ohms, and exposed a surface of 26 $^{\text{sq.mm}}$. It was fastened upon a small hinged lid, which, when shut, brought the working surface of the bolometer exactly opposite an aperture of the same size in the copper plate that formed the front surface of the sliding carriage, the bolometer in this position being otherwise completely enclosed in a copper lined cavity. The galvanometer used in connection with the bolometer was a very small instrument on Sir Wm. Thomson's plan with modifications by Prof. von Helmholtz. The mirror, on the back of which were cemented two minute bar magnets, was suspended by a single spider's thread 6$^{\text{cm}}$ long, so that there was no perceptible torsion. The deflections were observed by the telescope and scale method, and, as they never exceeded 10$^{\text{cm}}$ on the 126$^{\text{cm}}$ distant scale, they required no reduction. Under the influence of the earth's magnetism the mirror made a complete double swing in 1·5 sec., but was rendered so nearly astatic by means of a bar magnet below the galvanometer pier, that this time was increased to 15·0 sec., or, when a lamp was used as source of heat and the apparatus had to be rendered less sensitive, only to 8·4 sec. The galvanometer had a resistance of 173 ohms, and, although by no means specially adapted to the purpose, its performance in connection with the bolometer was in every way satisfactory. The current used was produced by two small Daniell's cells, and its strength, as indicated by another galvanometer, was so constant as to render corrections for change of current unnecessary.

The lamp, or other source of heat, was placed in front of the slit upon a shelf provided for the purpose, and all radiation except that passing through the slit was cut off by a large screen faced with bright tin plate, which formed the front of the apparatus. The exposure was made by means of a sliding shutter in front of the slit, which was opened by the observer at the galvanometer, when required, by pulling a cord. Further, in order to cut off extraneous radiation and air currents, the whole of the apparatus on the board was covered by a box of tin plate, and the upper end of the tube surrounded by protecting screens.

The manner in which this apparatus was used is apparent. The bolometer having been "balanced" and the mirrors and slit adjusted so that the image of the latter fell upon the bolometer aperture, heat from the source experimented upon was admitted by pulling the cord, and the galvanometer gave a prompt deflection which was noted by the observer. The tube being then filled with carbonic acid, which on account of its specific gravity could not escape, a smaller deflection was obtained, indicating a certain absorption in a column of gas double the length of the tube. It remains to describe the way in which the filling was accomplished.

A short glass tube passing up by the mirror through the bottom of the low stand could be connected at pleasure, by means of a length of clean rubber tubing, either with the gas generator or with a water air-pump in an adjoining room. The generator consisted of a bomb containing eight kilograms of pure liquid CO_2, from which a practically inexhaustible supply of gas could be drawn and the tube filled in as short a time as desired. By disconnecting the generator and connecting the air-pump the gas was withdrawn from the tube and ejected from the room.

Such being the nature and arrangement of the apparatus employed, the manner of conducting an experiment was as follows: The doors and windows were opened half an hour before the beginning of operations, and the air-pump connected and set going, in order to fill the room and tube with pure air. The room was then closed, the pump stopped, and a series of exposures made at noted intervals of about 1¼ minutes for half an hour or more, in order to form an idea of the constancy of the lamp (or other source), and obtain the rate of change of its intensity. Then, without disturbing the apparatus, the tube was connected with the reservoir and filled with CO_2, the moment of overflow being tested by means of a spark on the end of a wooden splinter, for which purpose a small offset tube had been provided, branching off from the large one near the top. In order to prevent air currents from disturbing the level of the gas, the mouth of the large tube was covered during the operation by a sheet of paper. When full, which was generally four or five minutes after connecting with the reservoir, the gas was nearly shut off, a very slight current being allowed to flow to supply the loss by diffusion, and several observations made as before with the galvanometer. These deflections were, in the case of the lamp, somewhat smaller than the first. The tube was then connected with the pump and the observations continued, the deflections increasing as the level of the CO_2 sank in the tube, and regaining their original value when the gas was all out.

As an example, I give the record of observations made on the 15th of March, the source of heat being in this instance the non-luminous flame of a Bunsen burner.

Time.	Deflec. in mm.	Time.	Deflec. in mm.	Time.	Deflec. in m
4h 27m	82·4	4h 52·5m	Filled with CO_2.	5h 18m	56·3
28	82·4	56·5	50·1	19·5	59·3
29	81·1	57·5	51·2	20·5	61·5
30	80·9	58·2	50·4	21	Gas nearly c
31	81·4	59	51·0	22	63·3
33	79·8	5 1	50·4	22·5	appar'tly all c
34	79·9	1·5	connected pump	23	69·8
36·5	79·7	6	50·4	25	73·0
39	81·0	7	50·1	31	73·0
40	78·7	12	51·6	32	72·9
48·5	80·3	13	52·2	34	73·5
50	80·2	14	52·9	39	72·8
51	78·2	16	54·5	40	74·0
52	78·4	17	54·6	41	73·5

If these observations be plotted on paper with abscissæ pr portional to the time and ordinates proportional to deflectior we obtain a curve showing graphically the absorption of tl rays from the burner at different times, and hence approx mately for different thicknesses of CO_2. From this curve v take at time 4h 57·5m deflection with air in tube 78·1mm; defle tion with CO_2 in tube 50·4mm reduced to time at 4h 57·5m.

This gives an absorption of 35·5 per cent. From a consi eration of all the observations an absorption of 35·8 per cei was taken as that due to the tube when full.

Let us now consider the absorptive media interposing b tween the source of radiation and the bolometer face before th admission of CO_2. We may disregard the glass chimney of th kerosene lamp, since we may regard the whole combination a forming a single source of heat, remarking, however, that a the glass is heated, and consequently radiates the same rays i absorbs, its absorptive effect is not so great as if it were place elsewhere in the path of the rays. Between the slit and th bolometer we have then four meters of air and three reflectin surfaces of silver. We have seen that the absolute absorptio of such a column of air must be very small, although doubtle many times that of such a vacuum as can be produced by a air-pump. The amount of CO_2 passed through in this distanc is from 1 to 2 millimeters. The silver surfaces have bee shown to exercise a general selective absorption, increasin gradually from the lower to the upper end of the spectru but nowhere exhibiting sudden changes. When the tube full of gas the conditions are exactly the same, except that 3 meters of the path of the rays lie in CO_2 instead of air. Tl proportion absorbed by the silver is almost precisely the san as before, that of the air may be neglected in either case, an we may therefore take the ratio of the deflections obtaine the two different circumstances as the proportion of the ıdiation transmitted by 3·4 meters of gas.

first source of heat employed was a kerosene lamp with rgand burner and glass chimney, and was more constant ıy of the sources tried later, the irregularities in a series ːrvations being only about one-half per cent of the aver- lue of a deflection. Three experiments gave an absorp- 7·1, 7·2 and 7·9 per cent, the mean of which is 7·4 per

next source was a copper plate heated from behind to a ust below redness by a Bunsen flame, so that all of the ɔns consisted of invisible rays. Of these 11 per cent bsorbed.

t was tried the feebly luminous flame of the Bunsen itself. This indicated a greater absorption than any of ıer sources, three experiments giving a mean of 35·8 ıt.

t was tried a source consisting as much as possible of ›us rays only. For this purpose I employed the lamp, against the slit on the inside a water-cell with thin ides, containing a thickness of $15{\cdot}3^{mm}$ water. This cell 90 per cent of the radiation from the lamp without tibly diminishing the brightness of the image on the eter, and a prism placed behind the bolometer aperture l a spectrum extending well up into the violet. No tion whatever was indicated in this experiment, which ːpeated under various conditions of the apparatus. The cell completely cut off the rays from the Bunsen burner. ılly, although the apparatus did not admit of experiments ıqueous vapor, the enormous absorbing power of water rikingly shown by a soap-bubble film stretched on a oop, which cut off 38 per cent of the rays from the n burner, or more than the 3·4 meters of CO_2. The soap n from which the film was obtained, when placed in the cell, indicated an absorption of the rays from the lamp cent greater than that of water.

hese results we may especially note the following facts: ıt the luminous rays of the spectrum are not appreciably ed by a column of CO_2 3·4 meters in length, whereas it een shown that these rays are strongly absorbed by an ɔheric column containing the same quantity of CO_2. The ce afforded by the eye, inasmuch as the gas appears ly transparent, is confirmed by direct measurement of ergy of transmitted luminous rays. 2. That as the range wave-lengths given out by the radiant source is narrowed toward a certain invisible limit, the absorption of the gas es greater and greater, corresponding to the production of an absorption band in the ultra red of a continuous spectrum. 3. That the absorption is very considerable, and hence cannot correspond to a narrow line, but rather to a broad and heavy band.

I therefore consider it most probable that to the action of CO_2 in the atmosphere is due one or more of the great gaps in the invisible part of the solar spectrum, which the discoveries of Professor Langley* prove to be much more extensive than had hitherto been supposed, but further regard it as certain that some other agent than this gas (which may not be water vapor, or possibly even of a gaseous nature), contributes essentially to the total absorptive power of the atmosphere, so that a method of analysis based upon this power, in which the effect of the second agent is neglected, cannot lead to correct results.

The strongly selective absorption of CO_2 is also shown by a single series of observations, such as that given at length above. The deflections of the galvanometer rise very gradually as the level of the gas sinks in the tube, being very little greater than at first when it has fallen half way, then increase rapidly as the last portions of the pure dense gas are pumped out, and continue to rise slowly for some time after. The latter rise is caused by the gas, which, during the time occupied in pumping out has become diffused upward through the tube, so that the air within contains a much greater percentage of CO_2 than before the beginning of the experiment, and the removal of which requires considerable time. This is best seen in the graphical construction, where these changes are represented by corresponding inflections in the curve. The strong absorption of the rays from the Bunsen flame is in accordance with what Kirchhoff's law would lead us to expect, since this flame consists principally of glowing CO_2 and H_2O. The absorption of rays from a source consisting entirely of heated CO_2 is still more marked, as was shown by Tyndall in one of his experiments, where one meter of CO_2 almost completely cut off the rays from a flame produced by burning carbon monoxide, CO, in the air. Thus the absorption spectrum of CO_2 would be the reverse of the spectrum of such a flame.

Berlin, April. 1884.

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* This Journal, xxv, March, 1883.

NOTE.—Since the above was written I have seen in Professor Langley's article on the determination of obscure wave-lengths (American Journal, vol. xxvii, March, 1884), that observations made at his observatory make it probable that the largest of the gaps referred to are of telluric origin.

ART. XXV.—*Triassic Insects from the Rocky Mountains;* by SAMUEL H. SCUDDER.

EARLY in 1882, Mr. Arthur Lakes, Professor in the Colorado School of Mines, discovered a bed of plants and insects near Fairplay, Colorado, in rocks much older than any that have before yielded insect remains west of the Great Plains; the two or three specimens he sent me were sufficient to prompt a more thorough exploration of the locality, which I was able to make the following summer, resulting in the discovery of a fauna and a flora of considerable interest.

The plants have been studied by Mr. Lesquereux,* who pronounces the species, some thirty in number, but in a very fragmentary condition, to belong to Permian types, and declares the evidence to be decisive on this point.

The animal remains consist almost exclusively of insects, and are two-thirds as abundant in species as the plants—an exceptionally large ratio in beds where both occur. These insects form an assemblage wholly different from anything before known and, in contradiction to what Mr. Lesquereux says of the plants, clearly belong to types of a more modern character than any the Paleozoic series has yet disclosed. It is not often that one may speak so positively in the discussion of fossil insects, especially when not a single one of the species and only the smaller portion of the genera found have been previously known. But in this case all but two or three of the specimens obtained (some eighty in number) belong to a group which of all Paleozoic insects has received the most attention, namely, the cockroaches. This great preponderance of cockroaches, and the fact that the few known genera found in this collection have hitherto been discovered only in Carboniferous and Permian rocks, would lead us at first to refer the beds in which they occur to one of the Paleozoic series; but the presence of the other forms, and even the characteristics of those which are referable to Carboniferous and Permian genera, unmistakably point to a later horizon.

Paleozoic cockroaches are distinguished from living types by the complete interdependence of two of the veins of the front wing, and by the fact that the anal veins of the same wings invariably impinge upon the inner margin, and never, as in existing forms, upon the anal furrow. For these ancient types the name of Palæoblattariæ has been proposed, and all Paleozoic cockroaches whose front wings are preserved (and we know them almost exclusively from these organs) fall into this group. So far as I can discover there is not a single exception to this difference between ancient and modern types. Since this was first stated five years ago the number of Paleozoic species has been increased 25 per cent, and it is still true.

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* On some specimens of Permian fossil plants from Colorado. Bull. Mus. Comp. Zool., vii, 243.

In the paper in which these points were first discussed no allusion was made to Mesozoic cockroaches, as none had been found in this country, and the illustrations we possess of the European species are in many cases by no means sufficient to expose their structure; their study was therefore left until the imperfection could be remedied. It was however recognized, though not stated, that Palæoblattariæ exist in Jurassic rocks; it is shown, for instance, by figures of Wealden species on the fifth plate of Brodie's work on the "Fossil insects of the secondary rocks of England" (London, 1845), and by Dr. Eugen Geinitz in his recent paper on the Dobbertin insects,* in which one species is figured from the lower Jura; but the great mass of Jurassic species are plainly more closely related to living forms, and neither in the independent existence of the veins which are characteristically distinct in Paleozoic types, nor in the course of the anal nervules, do they show any affinity to the Palæoblattariæ.

Eleven of the seventeen species of cockroaches, and five of the nine genera found at Fairplay belong to the Palæoblattariæ. These five genera are the following: Etoblattina (1 sp), Petrablattina (2 sp.), Anthracoblattina—very doubtful, the specimen being very imperfect—(1 sp.), Spiloblattina, nov. gen. (4 sp.) and Poroblattina, nov. gen. (3 sp.). Only four of the eleven species therefore belong to known genera and one of these is doubtful; but the difference is more marked than this; for the species referred to Etoblattina is an aberrant form with an excessively long internomedian vein; and both the species of Petrablattina agree in differing from those heretofore known to a very considerable degree. Of the new genera, Spiloblattina is very peculiar in the strongly divergent and then convergent curve of the externomedian and internomedian veins around a large stigma near the middle of the wing, unknown in any other cockroach, ancient or modern, so far as I know; but otherwise it is related to Etoblattina: while Poroblattina is more nearly related to Petrablattina, and especially to the two new species of that genus from this locality.

The average size of these Fairplay Palæoblattariæ is much less than that of the Paleozoic Palæoblattariæ in general. The average length of the front wings of the Paleozoic species is 26^{mm}; that of these Fairplay Palæoblattariæ, 16^{mm}. This fact has its value, for the Jurassic species are nearly all of very small size, and the wing-length of the remaining species from

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*Zeitschr. deutsch. geol. Gesellsch., 1880, p. 510.

Fairplay (i. e. those which do not belong to the Palæoblattariæ) is less than 8·5, ranging from 6·5–11·5^{mm}. This agrees completely with the size of Mesozoic species already known. The average of all the Fairplay cockroaches is less than 13·5^{mm}.

As to the six cockroaches from Fairplay which do not belong to the Palæoblattariæ, the characteristics of their venation, as well as their small size, show them to be closely allied to Jurassic forms, although the three or four genera to which they belong are distinct from any yet characterized. Two of them are distinctly allied to Rithma, a genus established rather loosely by Geibel for some species from the English Purbecks figured by Westwood. They all have a decided Mesozoic aspect, and would at once be considered Liassic or at least Jurassic by any one familiar with the forms already known from these deposits. They have on the other hand an entirely different aspect from any and all Paleozoic forms, and present no points of close comparison with any Palæoblattariæ excepting some of those mentioned above from the same Fairplay beds, notably with the genus mentioned under the name of Poroblattina, which one of the genera not a little resembles.

This resemblance is of special interest because it points out the method in which the change from Paleozoic to Mesozoic forms has taken place, and does not bear out the suggestion made in my memoir on Paleozoic cockroaches (based on a comparison of the venation of the front and hind wings of existing cockroaches), that the scapular and externomedian were the two veins which were amalgamated in the historical development of the group. For when we compare the series of genera near the boundary line of the departure of the Palæoblattariæ toward later forms (those Paleozoic cockroaches allied to Petrablattina) and especially those brought to light by the discoveries at Fairplay, we find that in the Mesozoic species at least, it is the mediastinal and not the externomedian vein which has blended with the scapular, although the externomedian also may become blended with the others in living types. This amalgamation has proceeded by the enlargement of the scapular area, which has crowded the mediastinal toward the base of the wing, whose few remaining branches finally become attached to the scapular vein, no trace of their former dependence remaining visible.

We have then at Fairplay an assemblage of forms altogether different from any thing hitherto found in the Paleozoic series on the one hand, or in the Jurassic beds on the other. They show a commingling of strictly Jurassic forms with a larger proportion of types which may be called Upper Carboniferous or Permian with a distinct Jurassic leaning. There is therefore a strong probability that the beds in which they occur belong to the intermediate formation, the Triassic.

If this should be proved, Mr. Lake's discovery will have an added interest, from the fact that almost nothing is known either of the plants or of the insects of this formation. Of the plants, it is only necessary to point out that in the paucity of data, the upper Paleozoic aspect of the few vegetable remains from Fairplay can have but a negative value beside the positive proof of the alliance of the insects to Mesozoic forms. Of Triassic insects our knowledge is exceedingly meager; a single neuropterous larva from the Connecticut valley is all that the formation has hitherto yielded in this country. In Europe we know of only four species, each, I believe, from a single specimen; one of these is a cockroach, but it is entirely different from any of the Fairplay species, and indeed from any other known forms, so that we get no light from this quarter.

It may be urged that as much the larger proportion of known Paleozoic cockroaches come from Europe, our own fauna being comparatively unworked, this discovery may only indicate for America an earlier advance within Paleozoic times toward later types. Besides the important consideration that this would be in direct opposition to what we know of subsequent periods in America, there are only two facts known to me among fossil insects bearing on this point, one in favor of this hypothesis, the other against it. The first is the recent discovery in beds at Kansas City, Mo., said by the state geologists to have eight hundred feet of Carboniferous rocks above them, of the wing of a heteropterous Hemipteron, which I have called Phthanocoris. In Europe no instance is recorded of any insect belonging to this great group of Hemiptera in Paleozoic rocks, the three or four Hemiptera so far found belonging to the homopterous division. The other fact is brought forward in my memoir on Paleozoic cockroaches, and is of far more importance, not only because it is of broader significance, but also because it is drawn from the same group as that under discussion. The Palæoblattariæ are divisible into two groups, the Mylacridæ and the Blattinariæ, the former of which is in point of structure the more primitive type. Now the Mylacridæ occur only in America and form indeed about two-thirds of the species known from this continent. In Carboniferous times, therefore, as regards cockroaches, America was *more* old fashioned than Europe, and we should look for the introduction of new elements earlier in Europe than in America; yet the better explored Carboniferous and Permian deposits of that continent have yielded no traces of anything akin to the Fairplay insects. The first appearance of any such is in Mesozoic strata, and notably in the Lias.

So far as I know this is the first attempt to determine the age of a deposit from its insect remains alone, and it is unfortunate for its acceptance by naturalists that the plants give it, to say the least, no support, but rather are deemed by one competent to judge, to be decidedly adverse to what is here claimed.

The paleontological contradiction shown in the plants and animals of the Fairplay beds is not unknown to American geology, as every one is aware, but I do not know that it has been pointed out in this country at this horizon or in this direction—the discordance appearing later in time, and the plants indicating a younger and not an earlier age than the animals. An exactly parallel case appears to be shown in Eastern Russia, for in discussing the poorer strata of Kargalinsk, which he refers to the Permian, Twelvetrees says, "as regards the flora [11 species] the list has a Paleozoic aspect, but a secondary one as respects the reptilian remains" [4 species cited].*

Exploration of the locality will continue, and it is hoped that future material may throw more light upon the question. It may, however, be added that the few other insects found appear to have no Paleozoic relations whatever.

ART. XXVI.—*On the Flexibility of Itacolumite*; by ORVILLE A. DERBY.

HAVING had many occasions for observing the extensive series of quartzose rocks known as itacolumite in the gold and diamond regions of Minas Geraes, Brazil, I have for some time entertained a suspicion that the peculiar property of flexibility would on investigation be found to be only a surface character. I have already shown (this Journal, vol. xxvi, p. 34) that much of the so-called itacolumite belongs to a higher geological horizon than that containing the flexible layers and that in the mountain of Itacolumi itself only a small part of the mass of the mountain is formed of the schistose beds of the lower series of quartzites in which alone, so far as I am aware, the property of flexibility has been observed. Even in the lower series flexible portions are rather uncommon, and the greater part of the mass is as rigid as any similar rocks.

Artificial openings into this series of rocks are extremely rare, and so far itacolumite has been studied in its natural outcrops only at the surface, in which it is generally impossible to determine exactly how much the original characteristics of the rock have been modified by weathering. For some time past I have been on the lookout for an opportunity for studying unweathered itacolumite in order to determine whether or not the flexible layers extend beyond the action of surface agencies. Such an opportunity was recently afforded by the newly constructed Rio and Minas railroad. This line, starting from the valley of the Parahyba, crosses the Mantiqueira division of the maritime range of mountains into the southern part of the province of Minas Geraes, and then follows the course of the Rio Verde, one of the headwaters of the Rio Grande branch of the Parana, in the mountainous plateau lying to the westward of the Mantiqueira. The cuttings are mainly through gneiss, in great part decomposed, but at several points narrow belts of itacolumite are also cut through. At a place called Jurumirim, the river and railroad pass by a short, narrow gorge through a high ridge of itacolumite extending from S.W. to N.E. In the sides of this gorge the rock is unusually well preserved and has been cut away to give passage to the railroad to within two or three meters of the drainage level. A few miles away to the northeast on the same ridge is the village of São Thomé das Lettras, famous for itacolumite quarries which have afforded beautiful flexible specimens. This locality is about fifty miles southwest of São João D'el Rei, a typical itacolumite locality, from which this formation has been traced continuously to and beyond the Serra de Itacolumi at Ouro Preto. Though the intervening region has never been examined, there can be little doubt that the beds here examined are identical and continuous with those of São João D'el Rei and Ouro Preto.

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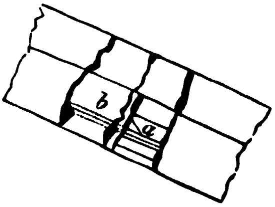
* Quart. Journ. Geol. Soc. Lond., xxxviii, 495.

This cutting exposed very clearly the rock in its natural state and as affected by percolating waters and surface agencies. The total thickness of the itacolumite series in the range of hills is not far from 100 meters, of which about 40 meters near the center of the series are laid bare in the cutting. Of these 40 meters the upper portion is composed of massive beds from one to three meters in thickness, in which flexible portions are rarely found. In the lower part the beds are more schistose or flaggy, and divide readily into laminæ of a few millimeters to a few centimeters in thickness, the greater part of which are more or less flexible. In this portion, water percolates freely along the planes of stratification and lamination as well as along the numerous joints, and it is difficult to find masses that can with certainty be pronounced to be in their original state. The beds strike N. 60° E., and dip to the N.W. at an angle of 30°.

Among the heavy upper beds the action of the weather and of percolating waters has been less general and an opportunity of comparing weathered and unweathered portions is afforded. The beds are traversed by fissures, and in the masses separated by fissures and stratification planes, massive and schistose, compact and friable, non-flexible and flexible portions may be found within a distance of a few centimeters, and in exactly the same relative position in the bed. Several such masses were observed, of which one is represented in the following figure.

The block, *b a*, about two meters thick and separated by open fissures from its neighbors on either side, is traversed near the middle by three cracks. From between two of these cracks a prism-shaped mass had fallen out, leaving an open space. Water percolating through these cracks has opened several concealed planes of lamination in the right-hand portion (*a*); while to the left of the cracks, although these planes are clearly indicated by faint lines of color, the stone shows no signs of yielding along them, and fragments detached with the hammer at *b* do not break along the dotted lines more readily than in any other direction. At *b* the rock is exceedingly hard and not at all friable or flexible, while at *a* it divides readily into slabs two or three centimeters thick, crumbles to sand with the pressure of the fingers and is slightly flexible. It should be stated, however, that in preparing a microscopic slide from the rock at *b* the thin slice showed a considerable degree of flexibility, though perhaps not more than other granular rocks which are not at all flexible in masses may exhibit under the same circumstances. My experience in making slides is not sufficient to enable me to form an opinion on this point.



The property of flexibility is best seen in the thin plates into which the rock splits along the planes of lamination, that is to say, in the direction of the bedding. Owing to the difficulty of detaching pieces of suitable shape it is not so readily exhibited in other directions. At several points, however, where thin slabs or irregular prisms had been separated by fissures transverse to the bedding, it was also observed. The planes of stratification and lamination are thickly covered with silver-white mica, but in the massive portions of the rock this mineral is not at all prominent.

From these observations it may be concluded that flexibility is not an original characteristic of the rock, but that, like the opening of the planes of lamination and the development of friability in hard granular rocks, which it accompanies, it is a phase of weathering or of the decay brought about by percolating waters. So far as known, it is limited in Brazil to beds of a certain definite geological horizon, apparently of Huronian age. It would appear, however, that it might occur equally well in any fine-grained and thin-bedded or laminated quartzite or ordinary sandstone. Further examination will very probably show that it is not limited to rocks of any definite horizon or to any well characterized natural division of the quartzose rocks.

ART. XXVII.—*On the Age of the Glazed and Contorted Slaty Rocks in the vicinity of Schodack Landing, Rensselaer County, N. Y.;* by S. W. FORD.

DURING the latter part of the month of May, after a day spent in the study of the Primordial rocks of the town of Stuyvesant, Columbia County, the writer made a hasty examination of the folded slates directly back of the Schodack Landing railroad station, near the Hudson River, and collected therefrom two poorly preserved, but yet decisive specimens of the well-known graptolitic species, *G. pristis.* It occurred to me at the time that the locality was one deserving more extended investigation; but owing to the pressure of other engagements, I was then prevented from entering upon the work. I have since, however, found opportunity to devote considerable time to the exploration of the region, and some of the more important results obtained are herewith communicated.

The slaty rocks back of Schodack Landing station, and their associated beds, occupy all the higher ground to the south as far as the Columbia County line, and are even prolonged a short distance into the town of Stuyvesant in Columbia County. In passing southward through Schodack Landing, they sweep westward as far as the Hudson River railroad track in two conspicuous promontories, and finally disappear altogether, about a hundred yards distant from the Stuyvesant Primordial beds,* a *fault* intervening. In these promontories the slates are excellently exposed, and are bent and contorted almost beyond description. They are fossiliferous at several different points, but especially so along the line of the Hudson River railroad, a short distance south of the county line, and about two hundred yards north of the residence of Mr. Patrick McCabe. At this locality there occurs a band of black slates, but slightly altered, which has thus far yielded the following ten species of Graptolites, described and figured on pages 265–274, plates 72–74 of the first volume of the Paleontology of New York, besides two others, probably new or undescribed:

G. pristis,
G. mucronatus,
G. sagittarius,
G. tenuis,
G. bicornis,
G. ramosus,
G. scalaris,
G. sextans,
G. furcatus,
G. gracilis.

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* Directly south of the more southerly promontory, the surface is low or marshy; and, after crossing this, the rocks at one point resemble those of the Hudson River group, although beds clearly of Primordial age occur only a few yards distant. It is possible, therefore, that the two groups have come into contact with each other, but I have not, as yet, been able to fully satisfy myself upon this point.

ddition to the above, I have also obtained from this band
young graptolitic forms figured on plate B of Decade II of
Geological Survey of Canada (1865), figs. 15 and 18. In
of all the evidence, I think there can be no doubt that
e slates are the exact equivalents of the Graptolite-bearing
of the Norman's Kill, near Albany. Stipes of the *G.*
tarius have been obtained here over a foot in length, and
f the species occur in a remarkably perfect state of preser-
on.[*]

he Norman's Kill slates were assigned by the New York
logical Survey to the horizon of the Hudson River group;
although doubts were subsequently raised by the investi-
ons of the Canadian geologists as to the correctness of this
ence, I became satisfied in 1871 and 1872, after an ex-
ation of the slates of various other localities on the west
of the Hudson River, that it was, in all probability, the
t one. Nevertheless, so long as the graptolitic testimony
he Norman's Kill beds remained unsupported by the evi-
e of other Hudson River group fossils at that locality,
ion appeared to me necessary in pronouncing upon the age
eds characterized by simply one or more of these species of
tolites, and not demonstrably their stratigraphical equiva-
s, in other places. For instance: in the summer of 1870, I
ined specimens of *Graptolithus pristis*, *G. scalaris*, and a
d species which I was unable to determine, from the slates
ediately east of the Hudson River at Troy; and later I
d good specimens of the first mentioned species in the
ed slates between Troy and Lansingburgh, along the line
he Troy and Boston railroad; but I did not consider this
lemonstrative evidence of the Hudson River age of the
s, although I now believe them to be of this age, in view
e new facts that have recently come under my observation.

ith the discovery of the rich graptolitic locality in the
nity of Schodack Landing, I at once resolved to institute
reful search for other fossils in the rocks of the neighbor-
d; and before quitting the field, my researches were re-
ded with success. Directly back of Mr. Honstein's black-
h shop, at Schodack village, there is a bed of limestone,
ut two feet thick, and, in part, somewhat brecciated in
earance, enclosed in the slates; and about a quarter of a
from the river, in the bottom of a deep gorge running
ward along the Columbia County line, the same limestone
d, similarly situated, is again met with. From the mode of

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he same or a similar band, abounding in the same species, occurs about a
south of Castleton, on an east-and-west road connecting with the regular
way from Schodack Landing to that village. It strikes obliquely across the
r highway only a few rods from the latter, or just beyond the residence of
ollins.

occurrence of this band, I have no doubt that it is a regular member of the slate formation. It is fossiliferous at both of the points referred to, and has thus far furnished the following species: *Asaphus platycephalus*, *Calymene senaria*, *Orthis testudinaria*, *Orthis lynx*, *Leptæna sericea*, *Strophomena alternata* and the hemispherical variety of *Chætetes lycoperdon*. None of the species of this locality are distinctive of the Utica slate, and both the limestone and its associated graptolitic slates represent, in my estimation, the Hudson River group. It is possible, however, that the Utica formation will yet be somewhere recognized among the folded and contorted rocks of the region.

In view of what I have recently and for several years past, observed in the field, the following propositions appear to me to rest upon a good strong foundation of facts, and will, I have little doubt, be fully sustained by future research:

1. That the rocks of the Hudson River group skirt the Hudson River quite extensively upon the east in Washington, Rensselaer, Columbia and Dutchess counties, or, at any rate, extensively enough to entitle them to continue to be called the Hudson River group; although the better plan would appear to be to discard altogether that designation, and go back to the old term "Lorraine shales."

2. That a great dislocation, bringing up (at least for a large portion of the distance) the rocks of the Primordial zone upon the east side of the line of fracture, and placing them upon the same level with, or even higher than, the rocks of the Hudson River group upon its western side, runs from western Vermont southward through the western portion of Washington, Rensselaer, Columbia and Dutchess counties; and that this dislocation does not strike across the Hudson River opposite, or so as to pass through Rondout, as some have supposed; but, on the contrary, before crossing, extends on southward beyond Rhinecliff station, in Dutchess county, for several miles.

3. That this dislocation probably occurred at the close of the Lower Silurian as urged by Professor Dana.

4. That over a considerable part of the territory traversed by this fault, the Primordial rocks wall against those of the Hudson River group unconformably; but that, in the majority of instances where they come together, the older beds have been made to overlap the newer conformably.

Johnstown, N. Y., July 5th, 1884.

ART. XXVIII.—*The Relations of the Mineral Belts of the Pacific Slope to the Great Upheavals*;[*] by GEO. F. BECKER.

PROFESSOR W. P. BLAKE first drew attention to the series of mineral belts of the Pacific slope and their striking parallelism to the mountain ranges, enumerating a considerable number of more or less continuous lines of ore deposits and stating their relations to the mountain system.[†] Mr. Clarence King accepted and enlarged upon these facts.[‡] All the structural features of local geology, he says, including the distribution of the precious metals are grouped in strict subordination to the longitudinal direction of the ranges, and these represent folds parallel to the main axis of the whole system of elevation. The deposits themselves he ascribes to the solfataric action accompanying the ejection of igneous rocks, and these eruptions he connects with the great orographical disturbances of the Jurassic and Tertiary eras.

It is fourteen years since the well known volume containing these statements appeared, and in the mean time great additions have been made both to the number of known ore deposits on the Pacific slope and to our knowledge of the geology of the region; contributions which throw some additional light on the relations between the broader facts of structure, and the distribution of ores. In most respects the statements made by Mr. King have been confirmed by subsequent information. The close relations between the folds represented by the ranges of the Pacific slope and the occurrence of ores is placed beyond question. Neither the ranges nor the deposits accompanying them however, have proved on the whole so continuous as it was once believed they might do. The mountain system of the Great Basin and Arizona may properly be regarded as a vast chain; the individual ranges being frequently interrupted and represented, but not continued in the direction of their trend, by fresh ranges. Similarly, while there is an evident tendency in almost every mining region west of the Rocky Mountains to prolongation in the direction of the trend of the mountains, comparatively few of the series of deposits are sufficiently continuous to be classed as mineral belts. Indeed it would now scarcely be claimed that there are more than four distinct ore belts on the Pacific slope, viz: the lead silver belt of Utah, the gold belt and the quicksilver belt of California, and the chain of deposits which extend diagonally across Arizona.

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[*] A part of the substance of this paper was first written for a Census report on The Statistics and Technology of Precious Metals, by Mr. S. F. Emmons and myself, now in press.

[†] Report to the California State Board of Agriculture, 1866.

[‡] Exploration of the 40th Parallel, vol. iii, Chap. 1.

In the Coast Ranges of California, quicksilver and chromic iron occur at a great number of localities. The most southerly quicksilver mine known to me is Las Prietas, four miles from Santa Barbara, and the most northerly the New Idrian, Douglass county, Oregon, localities separated by an interval of over 600 miles. There are considerable differences in the width of the strip of country embracing the known quicksilver deposits which are very numerous in the latitude of Mt. St. Helena and extend for a distance of about fifty miles in a northeast and southwest direction, or at right angles to the general trend of the belt, while to the northward of Clear Lake the deposits are few and are separated by long intervals. On the whole, however, it is strikingly apparent that conditions favoring the deposition of quicksilver ores have prevailed at numerous points within a belt in most places of small width and which is of great length. Messrs. Whitney and Gabb, as is well known, ascribe the elevation of the Coast Ranges of California to a post-Miocene uplift. The western edge of the area raised, or the present coast of California, is nearly parallel with, and for the most part very close to, the quicksilver belt.

The gold belt of California is extremely well defined from the southern boundary of Mariposa county to the neighborhood of Nevada City, a distance of about 150 miles, and near it is a series of copper deposits scarcely distant enough to be regarded as a separate system from a general point of view. Gold deposits are found in great abundance but more scattered to the northwest of Nevada county, and there is also a little gold to the south at a number of points along the foothills of the Sierra to its termination at Fort Téjon; in fact though the gold belt proper is comparatively short, there can be no doubt that a gold-bearing zone of country lies along the western foot of the Sierra for several hundred miles. This zone also coincides with the western edge of the great area of Mesozoic rocks which, as was established by the investigations of the California State Survey and the Exploration of the Fortieth Parallel, was uplifted after the close of the Jurassic.

The Utah ore belt lies at the western base of the Wahsatch range and its southwesterly continuation. With the exception of the Leeds (Silver Reef) district, all the important deposits of the territory are included in this belt, which bears a very definite relation to the main line of crests. The Wahsatch also forms the western edge of the Rocky Mountain area, which was uplifted at the close of the Cretaceous; the famous Wahsatch fault-line passing through or close to many of the mining districts.

Arizona deposits lie in a zone stretching entirely across
itory from southeast to northwest. This zone includes
lose to the dividing line between Paleozoic strata to the
st and the Archæan area of Southwest Arizona, depos-
rring both in the granites or crystalline schists and in the
ic limestones. The main contact between the Paleo-
l the underlying strata is laid down, in the geological
the Surveys West of the 100th Meridian, continuously
irgin Cañon to Camp Verde, a distance of 170 miles.
south the most westerly occurrences of Paleozoic shown
he Pinal mining district near Florence and in latitude
longitude 109° 40′. These are probably near the edge
rea, though there is some evidence of detached patches
her to the south, and to the west of the general course
ontact so far as traced. The Chiricahui range has been
y Mr. Gilbert to be largely made up of Paleozoic strata,
mines of the Tombstone district are many of them sunk
sits in limestone. In this region limestones can hardly
r than Paleozoic, and they are reported as containing
ferous fossils.

rocks adjoining the Paleozoic to the southwest are un-
ably Archæan, for their relations to the Silurian are
a great number of points, and their lithological charac-
his region is very characteristic and persistent. The
the Paleozoic has also been followed by Mr. Gilbert in
rly direction into California, near Owens Lake, whence
e is deflected to the north (Mesozoic strata, in part over-
rchæan, coming in on the west) and it crosses the
parallel in longitude 117° 30′. The mines of Battle
in, Austin, Candelaria, Cerro Gordo and Panamint all
e to the contact. Scarcely anything is known of the
of the region north of Battle Mountain, but Mr. Meek
ned fossils collected on the northern boundary of the
States at the 114th Meridian by Mr. Geo. Gibbs as Car-
us,* and it is probable that the contact passes through
ing region of Idaho.

western edge of the Paleozoic in the belt of country
d by the Exploration of the Fortieth Parallel represents
ctural line along which the Paleozoic area of Eastern
and Western Utah was uplifted at the close of the Car-
us. In Arizona faults practically parallel to the trend
ontact are known to have had an important influence
orography of the belt of country in which the contact
Archæan and Paleozoic occurs, but how far if at all
ent exposure of Archæan is due to the erosion of Pale-

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* Bull. U. S. Geog. and Geol. Surveys, vol. ii, p. 351.

ozoic strata has not been determined. The similarity and continuity of the two areas, however, give color to the supposition that in Arizona also the present contact substantially coincides with the line of post-Carboniferous uplift.

The mining districts on the western edge of the Paleozoic near and north of Owens Lake are at distances from one another too great to justify their being regarded as constituting a belt if taken by themselves, but when their occurrence is considered in reference to the Paleozoic area it seems difficult to avoid the conclusion that they really form a continuation of the Arizona belt.

A conclusion of economical importance evidently follows immediately from the facts set forth, quite independently of any theory whatever. It appears that a great majority of all the profitable ore deposits west of the crest of the Wahsatch occur in belts a few miles in width which follow the western edges of distinct geological areas, the Cretaceous in Utah, the Paleozoic, and usually the Carboniferous, in Nevada and Arizona, the Jura-Trias in Eastern California and the Cretaceous and Tertiary in Western California. Analogy therefore points to the neighborhood of the portions of these contacts still remaining unexplored as the most promising for future discoveries. Geologically it seems impossible to avoid the conclusion that the profound disturbance of the rocks in the neighborhood of these contacts was a condition of the deposition of the ores, thus establishing for these cases an intimate connection between the great events of geological history of the genesis of ore deposits. The upheavals, however, cannot in general have been the immediate causes of the formation of ores, for some of the most important bodies occur associated with later volcanic rocks in such a manner as to prove them far more recent than the upheavals. This again indicates that the fractures which attended some of these great orographical changes have continued through whole epochs unrepaired, as indeed is known in part from other evidence.

San Francisco, office of the U. S. }
Geol. Survey, May, 1884. }

T. XXIX.—*Notice of the remarkable Marine Fauna occupying he outer banks off the Southern Coast of New England, No.* 9; y A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. LV.

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Work of the Steamer Albatross in 1883.

DURING the summer of 1883, the new U. S. Fish Commission amer, Albatross,* Lieut. Z. L. Tanner, commander, continued work of dredging in the region of the Gulf Stream, along · coast, from off Cape Hatteras to Nova Scotia.† She is, in istruction, well adapted to do deep-sea work, and fully iipped with improved apparatus, and therefore was able to ry the dredgings much farther out to sea than the Fish wk had been able to, in previous years. The stations most tant from the coast were more than a third of the way to the rmudas. The greatest depth successfully dredged was in 49 fathoms, at station 2099, N. lat. 37° 12′ 20″, W. long. ° 39′, August 2. Besides this, there were four successful uls in 2033 to 2369 fathoms, and 27 between 1000 and 2000 homs. Between 500 and 1000 fathoms there were 19 hauls, d in less than 500 fathoms, 63, making a total of 116 itions. At nearly all these localities a large trawl was used, d in many cases large quantities of specimens were obtained, en at great depths. The bottom temperatures between 1000 d 2000 fathoms were usually between 37° F. and 39° F., and rely, 40° (in one case, at station 2050, 49·5° was recorded in 50 fathoms, and at station 2052, on the same day, 45°, in 98 fathoms, but these cases may have been due to some accintal cause, for at the same date other trials, at similar depths, ve 39°; I have therefore omitted these two temperatures, in e table). Besides the ordinary temperature observations, numerous serial temperatures, not given here, were also taken, and the specific gravity of samples of water, from various depths, was determined. The bottom at all the stations below 1000 fathoms was mainly composed of "Globigerina ooze," usually having the consistency of fine sticky mud, commonly of a dull olive-green or bluish color.* When washed through a very fine sieve a variable, but often large, proportion remains on the sieve, composed chiefly of the shells of *Globigerina* and other foraminifera, of many kinds, but mostly minute. These are usually mixed with a considerable amount of very fine grains of siliceous sand,† among which are some grains of magnetite and garnet. Green grains, apparently of glauconite, are also common.

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* Descriptions of this steamer and of her equipment, as well as of some of her ps, have already been published in Science. An account of the Crustacea was blished in the July number of this Journal by Professor S. I. Smith, who has o published a detailed account of that group, with figures, in the Fish Commisn Annual Report, part x. The writer has published a paper on the Mollusca, th five plates, in the Trans. Conn. Acad., vol. vi. Some of the new fishes have en described by Messrs. Gill and Ryder.

† The naturalists associated with the writer, in this work, in 1883, were Prosor S. I. Smith, Mr. Sanderson Smith, Professor L. A. Lee, Mr. Richard Rathn, Mr. J. H. Emerton (also as artist), Mr. B. F. Koons, Professor Edwin Linton, r. H. L. Bruner, Mr. J. E. Benedict (naturalist attached to the steamer), Mr. S. Tarr, W. E. Safford, Ensign U. S. N., and others, more or less. Mr. Peter rker, Mr. John A. Ryder, Dr. Theodore Gill, and R. H. Miner, Ensign U. S. N., rked on the fishes. The parties who went out dredging, on the steamer, varied m time to time. Usually only three or four naturalists, besides Mr. Benedict, uld be properly accommodated on board. I took no part in this portion of the rk, in 1883, not going out on the steamer at all.

The deepest localities were all rich in animal life, of many kinds. A considerable number of interesting fishes were obtained, many of them new to our fauna. Some of these are new genera and species of great interest.

Very interesting additions to our collections were made in nearly every class of marine invertebrates, including many undescribed species and genera, some of which are of great morphological importance, while many of the described species were previously known only from distant regions, on the European side of the Atlantic, in the arctic or antarctic regions, off the coast of South America, in the West Indies, or even in the Indian or Pacific Oceans. Thus our knowledge of the distribution of the deep-sea forms, both geographically and in depth, has been greatly increased. Some of these deep-sea species were first described as fossils from the European tertiaries. Moreover a considerable number of our shallow-water species have been found to have a much greater range in depth than was anticipated, many of them going down below 500 fathoms, while some even go below 1000 fathoms.

On the first trip of the Albatross from Wood's Holl, which was made July 16th to 19th, four successful hauls were made with a large trawl, in 1346 to 1735 fathoms, on the 17th and 18th of July, two each day, besides the soundings and tempera-

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* In recording the character of the bottom, on the vessels, the character of the mud is usually judged of mainly by its appearance to the naked eye, and sometimes by the sense of touch. The finer varieties of "globigerina ooze" are not distinguishable by these tests from "fine blue mud," or "sticky mud," or "fine gray mud." Nor are the coarser foraminifera always distinguished from "sand" or sandy mud." Thus the official records of this and other similar explorations do not always agree with the determinations of the naturalists who subsequently examine the samples of bottom. In many cases, however, such corrections are eventually made. Very perfect samples of bottom-mud are often enclosed in the hollow, bulbous bases of large *Actiniæ*. Such samples, not having been washed free of their finer portions, might often serve to supplement or correct the official records made from the samples brought up in sounding.

† The *sand* probably floats out on the surface to these distant localities from the *shore beaches*, as explained in my former papers in this Journal.

tial List of Stations occupied by the Albatross in 1883.

Most of those in less than 500 fathoms are omitted.

Locality.		Fath.	Bottom.	Date.	Temp. F.		Hour.
					Bottom.	Surface.	
Lat.	W. Long.						
27′ 10″;	69° 56′ 20″	1346	glb. O.	July 17			
26 12;	70 02 37	1362	“ “	17			
52 40;	69 24 40	1735	“ “	18	38°	76°	4.30 A. M.
53 00;	69 23 30	1731	“ “	18	38	76	1.22 P. M.
30 30;	69 08 25	2033	“ “	26		76	2.32 P. M.
19 26;	68 20 20	2369	“ “	28		81	noon.
35 13;	68 16 00	2226	“ “	29		76	4.20 A. M.
22 50;	68 25 00	1608	“ “	30	38	72	3.50 A. M.
33 00;	68 26 45	1555	“ “	30	38·5	71	10.32 A. M.
49 00;	68 28 30	1467	“ “	30	38·5	72	5.07 P. M.
00 30;	68 37 20	1067	“ “	31	39	72	5.25 A. M.
04 20;	68 43 50	373	bu. M., fine Sh.	31	40	72	10 A. M.
02 49;	68 49 00	407	bu. M.	31	40	72	noon.
02 30;	68 49 40	389	“ “	31	52	72	2.15 P. M.
02 00;	68 50 30	547	crs. S., M. & G.	31		72	3.56 P. M.
43 40;	69 20 00	1025	bu. glb. M.	Aug. 1	39	71	3.35 A. M.
43 50;	69 21 20	1050	glb. O.	1		72	9.15 A. M.
41 00;	69 20 20	1106	“ “	1	39	72	2.34 P. M.
40 05;	69 21 25	1098	“ “	1		73	6.16 P. M.
53 00;	65 35 00	858	gy. M.	Sept. 2	39	56	6.15 A. M.
54 15;	65 39 00	586.5	gy. S.	2	40	58	10.41 A. M.
43 00;	65 21 50	1309	fine glb. M.	3	40	69	6.42 A. M.
40 30;	65 35 00	855	“ “ “	3	39	58	3.41 P. M.
13 00;	66 00 50	906	bu. glb. M.	4		69	3.20 A. M.
09 40;	66 02 00	1255	“ “ “	4	39	68	8 A. M.
26 40;	67 05 15	959	gy. M.	5	40	72	4.30 A. M.
16 50;	67 05 15	1290	bu. M., S. F.	5	40	78·5	9.09 A. M.
42 50;	71 01 20	1000	F. S. M.	21	39	69	1.12 P. M.
44 30;	71 04 00	1022	“ “ “	21	38·5	68	5.07 P. M.
29 00;	70 58 40	1342	glb. O.	30		69·5	9.02 A. M.
22 20;	70 52 20	1451	“ “	30	37·5	69	2.07 P. M.
ff Chesapeake Bay.							
56 20;	70 57 30	1917	“ “	Oct. 1		72·5	5.30 A. M.
40 30;	70 37 30	2221	“ “	1		72·5	1.08 P. M.
12 20;	69 39 00	2949	“ “	2		82	5.30 A. M.
ff Delaware Bay.							
22 00;	68 34 30	1628	“ “	3	37·5	69	11.05 A. M.
18 30;	68 24 00	1686	“ “	3	37	67	4.31 P. M.
44 00;	72 38 00	1209	“ “	Nov. 5	39	62·5	
47 20;	72 37 00	1091	“ “	5	39	62	
48 00;	72 40 30	991	bu. glb. M.	5	45·5	63	
ff Chesapeake Bay.							
50 00;	73 03 50	1395	glb. O.	6	41	63	
41 20;	73 03 20	1497	“ “	6	41·5	63	

ture determinations, including series of temperatures at various distances from the surface. On this trip about 105 species of Invertebrates were obtained, not including the Foraminifera and other minute forms. There were among these 14 species of Anthozoa; 2 of Hydroids; 22 of Echinoderms; 38 of Mollusca; 15 of Crustacea; 1 of Pycnogonida; 10 of Annelida; 1 of Bryozoa; 2 of Sponges.

The Echinoderms were among the most abundant and interesting of the deep-sea animals. About sixty species were dredged by the Albatross, many of which are new to our coast, though previously dredged on the European side, or in the Caribbean Sea and still more distant regions. Others are undescribed forms. Among the Holothurians were two gigantic species, belonging to a peculiar deep-sea family of which many species were brought to light by the Challenger expedition. These occurred in large numbers at several stations, mostly between 1000 and 1500 fathoms, in some cases more than a barrelful of one of them coming up in a single haul. The largest and most singular one is a new species of *Benthodytes* (*B. gigantea* V.)* which is a very large, oblong, massive species, flat below and convex above, sometimes 18 inches long and 5 or 6 broad, having a gelatinous, translucent appearance, but with a firm cartilaginous texture when fresh. The cartilage-like walls of the body are very thick, often an inch or more, and the visceral cavity is very small in proportion. Owing to the dense and impervious, cartilage-like tissues, this species is very difficult to preserve in alcohol, the interior decaying before the fluid can penetrate the tissues, even when the visceral cavity is cut open.

The second species is also a new form, *Euphronides cornuta*

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* *Benthodytes gigantea* V. Body massive, usually elliptical or oblong, broadly rounded at the ends, strongly convex on the upper surface. The whole dorsal surface is smooth and lubricous but covered with numerous, minute, soft papillæ, both above and below. On the upper surface two alternating rows of rather small, tapered ambulacral papillæ run from one end to the other, on each side, about midway between the center and margin, but these usually stand so nearly in line as to appear like a single row, consisting of about eleven papillæ. The margin is crenulated, each crenulation is surmounted by a small, tapering papilla, or modified sucker. The mouth is situated on the under side, a short distance from the anterior margin. The tentacles are twenty, short and thick, terminated by a group of small conical papillæ. The cloacal opening is situated on the upper surface, close to the posterior margin. Two rows of small suckers occupy the median ambulacrum on the posterior half of the ventral surface; the two rows are a short distance apart and often lie in a more or less sunken groove; there are about twelve suckers in each row, the anterior ones smaller and farther apart. The color is translucent, pale flesh-color, or purplish white, reticulated with whitish lines or wrinkles, and sometimes irregularly mottled above with dark purple or dull orange, deeper toward the margin. Ventral suckers and tentacles dark purplish brown. Length of the largest specimens, about 18 inches, breadth, 6. Ordinary specimens, in alcohol, are from 250 to 300^{mm} long by 75 to 100^{mm} broad, and 50 to 70^{mm} thick.

,* related to *E. depressa* of the Challenger expedition. It s two pairs of large, elevated, teat-like anterior tubercles, to ich character the name refers. In form it is not unlike *B. antea*, but it is smaller, narrower, less massive, and has a uch thinner, reddish brown integument, without the car-aginous character of the latter.

The starfishes were very numerous in the deep dredgings d are represented by many interesting species. The most undant starfish was a fine, new, orange-red species of *Zoroas-*, of large size, with slender spinose arms, (*Z. Diomedeæ* V.)† bout 200 specimens of this occurred at station 2035. It was ken at many stations, in 1000 to 1600 fathoms. The most mmon genus, as usual in very deep water, was *Archaster*, of ich numerous species occurred. Many of these are very large and handsome, and are generally orange or orange-red in color. Several are unlike those species from less than 500 fathoms, taken by the Fish Hawk. A large, rather smooth *Archaster*, with a very large madreporic plate (*A. grandis* V.,)* and a remarkably spinose species of a related genus (*Benthopecten spinosus* V.),† were associated with the *Zoroaster* at station 2035 and elsewhere, generally between 1000 and 2000 fathoms.

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* *Euphronides cornuta* Verrill, sp. nov. A very large species, oblong in outline, h both ends rounded, the upper surface strongly convex, the lower flat, in nsverse section nearly semicircular. On the upper surface, a little in advance the middle, are two very large, divergent, blunt tubercles, often more than an h in length, usually swollen at base, with a narrow central tube. A little in nt of these is a similar but smaller pair, usually about half as large, the size l shape varying according to the state of contraction. In front of the second r there are usually about four pairs of much smaller tubular papillæ, the ante-r ones smallest. At about the posterior fourth there is a very large, double dian tubercle, swollen at base, rounded or emarginate at the summit, and ter-nated by a pair of tubular verrucæ. An orange-brown longitudinal band runs ng just outside the bases of all these tubercles, on each side, and branches go m these to the central tube of each tubercle. The margin is thin, with small llops all around, between all these there is a small prominent papilla or modified ker. The mouth is situated on the under surface, at about the anterior sixth; tacles eighteen, short, blunt, thick, covered with small papillæ. Cloacal open-; situated on the under side, near the posterior end. A median ambulacrum, ible through the skin, runs between the two openings, with two alternating vs of small suckers near together. The general color is dull flesh-color, or pale wnish, usually with fine specks of orange-brown. The dorsal and submarginal bulacral bands and their branches running to the suckers and tubercles are p purplish brown, fading to orange at the margin; the bands are bordered on h side by white or pinkish. Tentacles, buccal and cloacal regions dark pur-sh brown. The whole lower surface is often purplish brown, reticulated with rker lines or wrinkles. When distended the skin is more or less translucent, th a somewhat gelatinous appearance, but in contraction it becomes more aque and darker colored. The whole surface is roughened with minute dermal ates. Length of an ordinary specimen, 300^{mm}; breadth, 70^{mm}; height, about ^{mm}.

† *Zoroaster Diomedeæ* V., sp. nov. Arms five, long, slender, tapered, angular ove, with three or five rows of acute spines; one median dorsal, and one lateral, r in large specimens two, on each side; these spines arise from rows of promi-ent close plates; the surface between is covered with small sharp spines; two r more rows of large single pores between the dorsal and lateral rows of plates; hree to five rows of smaller lateral plates along the sides of the rays, with rows f pores between; each plate bears a single long, slender spine and several much maller ones. Four rows of suckers on the basal part of arms. Adambulacral lates alternately unequal; the larger ones bear each a transverse row of four or ive slender, sharp spines; the inner spine projects inward between the suckers nd bears 3 to 12 large, elongated, tapering pedicellariæ. Similar large pedicel-ariæ are scattered over the back and sides. Madreporic plate very small. Color n life orange or orange-red. Greater radius of a large one, 150^{mm}; lesser radius, 13^{mm}.

The Anthozoa were abundant, both in individuals and species, in most of the dredgings below 1000 fathoms. About 40 species were taken, altogether, belonging to all the principal groups. Several were undescribed, while others are new additions to our fauna, though previously obtained elsewhere by the Blake or Challenger. It was also a source of satisfaction to us that we rediscovered, in larger numbers, the few remaining species that the Blake and Challenger had obtained off our coast, but which we had not previously dredged.

Among the Pennatulacea there are some highly interesting forms. The remarkable deep-sea genus, *Umbellula*, originally discovered off the coast of Greenland, but hitherto unknown off the eastern coast of North America, though recently dredged in most other parts of the deep oceans by the Challenger and other expeditions, is represented by several large and fine specimens belonging to two species, one of which is probably *U. Guntheri* Kölliker, taken by the Challenger in the eastern Atlantic, while the other, *U. Bairdii* V.,* seems to be new. In this genus there is a handsome cluster of large flower-like polyps at the summit of a tall slender stem.

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* *Archaster grandis* V., sp. nov. Five long, slender, tapering arms; disk small pentagonal, with concave sides. Dorsal surface unusually smooth, covered with small paxillæ, having minute spinules; among these are scattered three-bladed pedicellariæ. Madreporic plate very large, convex, covered with stellate groups of small spinules, larger than the paxillæ. Lateral plates squarish, the upper and lower about equal and opposite, each bearing a single moderately large, tapering spine, but in the interbrachial spaces the lower ones often bear two or three; surface of plates covered with small spinules. The ventral plates, which cover a triangular space, bear small divergent spinules, often with a larger central one. Adambulacral plates bear a curved, longitudinal group of 8 to 10 close spines, the central ones longest. Oral plates prominent, spinulose, with an oval naked space in the middle between them, and margined by many short oral spinules. Larger radius, 110^{mm}; lesser, 17^{mm}; diameter of madreporic plate, 10^{mm}.

† *Benthopecten spinosus* V., sp. nov. Rays five, long, rather slender, except at base flat, and gradually tapered to long narrow tips. Disk not very large and like the arms covered with a smooth skin and covered plates, each with a slender central spine; these become larger toward the center, where there is a group of about 20 long, erect, tapering, sharp spines. A circle of 4 to 6 papillæ, placed singly, surrounds each plate. There are neither paxillæ nor granules. Upper marginal plates rather small, elevated in the middle, more than 40 on each side; each bears several minute spines and a single central, large and long, tapered, sharp spine, the basal ones and those bordering the disk becoming larger and exceeding those of the center of the disk. Lower marginal plates bear each a vertical row of about 3 spines, the upper one much the longest, and along the middle of the arm as long as those of the upper plates, but becoming much smaller at the base of the arm and along the disk, where the latter increase in size. The ventral plates form small triangular areas; they are rounded, raised in the middle, and each bears one or two small acute spines, but no granules. The adambulacral plates project strongly inward, and each bears an inner convex row of 4 or 5 small, slender spines and a transverse outer row of much larger ones, of which one or two inner are much the largest. Suckers large, tapered, pinched up at tip. Larger radius, 150^{mm}; smaller, 22^{mm}. Still larger examples were taken. Station 2035, in 1362 fathoms, etc.

Benthopecten, gen. nov., resembles *Archaster*, but differs in having no paxillæ; the dermal plates usually bearing a single spine, sometimes two or three.

Another new species, which was taken in 1362 to 2369 fathoms, belongs to the genus *Kophobelemnon* (*K. tenue* V.)† This genus we had not previously dredged, though a single specimen of a different species (*K. scabrum* V.) had been obtained by the Blake expedition in 1880. This was also taken by the Albatross in 789 fathoms. A very elegant species, apparently new, belonging to the genus *Scleroptilum* K., hitherto known only from off Japan, occurred in large numbers at several stations, in 1467 to 2369 fathoms. This I have called *S. elegans.*‡ It nearly always had a new species of *Astronyx* (*A. tenuispina* V.)§ clinging closely to it, which, like its host, was bright orange.

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* *Umbellula Bairdii*, sp. nov. Stalk very tall and slender; axis quadrangular, with concave sides; basal bulb long, narrow; rachis short, swollen. Polyps eight or nine, bilaterally arranged, large, long, very smooth, with long, slender, regularly pinnate tentacles. Zoöids simple, small, numerous on all sides of the rachis, running up on the sides in lanceolate groups between the polyps; a few extend down in a row on each side of the upper part of the stem. Color, deep orange-brown. Height, 400 to 500^{mm}; diameter of stem, in middle, 3 to 4^{mm}. Stations 2036 to 2038, in 1731 to 2033 fathoms.

† *Kophobelemnon tenue* V., sp. nov. Tall and slender, with a long thin stalk and a long rachis, only a little thicker. Polyps large, short, alternate, in a regular row on each side, well-separated. Zoöids small, not crowded, forming a band on each side of the back, leaving the middle naked, and running up in lateral groups between the polyps: a few are scattered on the ventral side. Spicula small and abundant. Color of stem and rachis light yellow; of zoöids orange-brown. Height, 4 to 6 inches. Stations 2035, 2038, 2039, in 1362 to 2369 fathoms.

‡ *Scleroptilum gracile* V., sp. nov. Slender, with the polyps occupying more than half the length. The polyps are large, arising from large and somewhat conical incurved calicles, which are swollen at base and covered all over with an abundance of small slender spicula. The calicles are frequently opposite, or nearly so, but more generally alternate; the lower ones become gradually smaller and more scattered, and very small ones extend for some distance down the stem, which is very slender, with a long narrow bulb. The zoöids are small but prominent and scattered along the ventral side, mostly in groups of 3 to 6 alternating with the pairs of polyps, but often they occur also between their bases. Color orange in life, yellowish white in alcohol. Height, 185^{mm}; of polypiferous portion, 110^{mm}; breadth across contracted polyps, 3 to 4^{mm}; diameter of rachis and stem, 1 to $1{\cdot}5^{mm}$; length of calicles, about 3^{mm}; diameter at base, 2^{mm}. The swollen bases of the calicles are often filled with eggs. Stations 2036, 2038, 2039, 2041-3, in 1467 to 2309 fathoms.

§ *Astronyx tenuispina* V., sp. nov. A species with a pentagonal disk and five long slender arms, much resembling *A. Loveni*, but easily distinguished by having, instead of hooks, three slender, divergent arm-spines, of which the lower is much the longest and largest, with the distal end enlarged and roughened by little spinules. The genital openings are situated as in *A. Loveni*, but not quite so near together. Mouth-papillæ small and short; the jaws end in a single short spine-like papilla. Color orange, in life; white in alcohol.

Perhaps this ought to constitute a new genus, on account of the spines.

Among the other interesting Pennatulacea is *Anthoptilum Murrayi* K., which was dredged several times in 640 to 1362 fathoms. It was first taken off Nova Scotia by the Challenger. It was associated, in some cases, with the much larger *A. grandiflorum* V., first described by me in this Journal from numerous fine specimens obtained by the Gloucester fishermen on the banks off Nova Scotia, but afterwards described by Kölliker as *A. Thomsoni* from specimens dredged by the Challenger off Buenos Aryes, in 600 fathoms.

The Gorgonacea are represented by several fine species, some of them conspicuous on account of their large size and bright colors. The bush-like *Acanella Normani*, as usual in deep water, occurred abundantly. *Lepidisis caryophyllia* V., which grows in the form of tall, slender, unbranched stems, often two or three feet high, with long, hollow, calcareous joints, alternating with short horny ones, and with very long spiny calicles, occurred alive several times, in 1098 to 1735 fathoms, and dead in many localities, where its joints are very abundant on the bottom and afford solid support for the attachment of other species of Anthozoa, etc. Fine living specimens of *Acanthogorgia armata* V. were taken in 407 to 640 fathoms, and a number of specimens of *Primnoa lepadifera* were dredged on the outside of Brown's Bank, off southern Nova Scotia, in 101 to 131 fathoms. A very elegant plumose coral, the *Dasygorgia Agassizii* V., which has a slender, iridescent, calcareous axis, with the main branches spirally arranged and the large polyps obliquely seated, was dredged in 1346 to 1362 fathoms. It belongs to a peculiar deep-sea family, Chrysogorgidæ,* recently established by me for this and several related genera, nearly all of them elegant in form and colors. A new genus, belonging to this family, was dredged in 858 to 1735 fathoms (*Lepidogorgia gracilis*).†

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* Blake Anthozoa, Bulletin Mus. Comp. Zool., xi, p. 21, 1883.

† *Lepidogorgia*, gen. nov. Axis simple, iridescent, with calcareous, ramose roots; polyp-cells large, oblique, covered with fusiform spicula; cœnenchyma thin, covered with small oblong scales.

Lepidogorgia gracilis V. Axis tall, slender, terete, tapering to a flexible tip; roots large, thick, irregularly but finely arborescently branched, the branchlets white, round, tapering and coral-like. Polyp-calicles large, prominent, distant, obliquely seated, often thicker than the stalk, covered with large spicula, longitudinally placed. Spicula of the cœnenchyma small, flat, oblong, or constricted in the middle, with rounded ends. Color, when fresh, orange or salmon. Height, often 900^{mm} or more; diameter of axis, at base, 1–1·5^{mm}; of polyps, 1^{mm}; distance between polyps, 5 to 10^{mm}. Station 2072, off George's Bank, in 858 fathoms; stations 2036 and 2037, in 1735 and 1731 fathoms. A large lot from station 2037.

ART. XXX.—*Geology of the Blue Ridge near Balcony Falls, Virginia; a modified view*; by JOHN L. CAMPBELL.

IN this Journal, vol. xviii, Dec. 1879, will be found a paper on the geological structure of the Blue Ridge, at Balcony Falls, Rockbridge County, Virginia, illustrated by a map and geological section. As to their main features the facts there presented are correct; and the descriptions given have been corroborated by subsequent observations—at least so far as relates to the Cambrian formations that rest against the western flank of the igneous and metamorphic core of the Blue Ridge at this point.

But, as regards the stratified beds flanking the main ridge on its eastern slope, subsequent observations have modified the views expressed on page 439 of the paper referred to above, where the following paragraph occurs:—

"The bedded rocks (1, *a b*,) that rest upon the syenite are very much metamorphosed, are gneissoid in character, and dip toward the southeast. [Correct so far]. Then follows a bed of forty or fifty feet of conglomerate and quartzite, bearing some resemblance to the conglomerate sandstones on the opposite side of the ridge, but so different in composition, texture, position and thickness as to preclude the idea that they have any historical connection. Over this again we find another bed of slate. These beds all dip toward the southeast while their upper margins reach beyond the underlying syenite and granulite, and with their edges support the lowest beds of Primordial rocks, where both extend high up on the ridges, beyond the limits of the igneous beds."

It was a mistake, as will appear farther on, to class these as *Archæan beds*. But some apology may be found for my mistake in the fact that Prof. W. B. Rogers, in his notes on the geology of Virginia, as found in Macfarlane's Geological Railway Guide, speaks of the rocks between Lynchburg and Balcony Falls as all belonging to the Laurentian and Huronian (his A and B) formations. I had not, however, seen that note of his before the paper above quoted was published; so that I am entirely responsible for my own partially erroneous conclusion.

After my paper on this subject had been published, suspicions arose in my mind that the conglomerate and slate beds along the eastern flank of the main Blue Ridge might be of Cambrian age, and so modified by the metamorphic agencies as to have their characteristic features obscure; but engagements elsewhere diverted my attention from them until recently.

My assistant, Mr. Harry D. Campbell, and myself were requested, a few months ago, to make a professional examination of a belt of slate lying along the southeast base of the Blue Ridge in the western corner of Amherst county. In this belt the "Snowdon Slate Quarries" have been opened, and on tracing its strike toward the southwest it was found to cross the James River a little beyond the limit of the map and section referred to above.

While examining the geological relations of the belt of slate, my assistant discovered that one of the beds of sandstone underlying the slate, abounded, at some points, in *Scolithus borings.* Examinations extended lower down the River on the Amherst side disclosed several alternations of sandstones, conglomerates and slates, all dipping toward the southeast, but with decreasing steepness until, as they approach the old ferry where the Richmond & Alleghany Railway crosses the river, they become approximately horizontal. Then changing their dip toward the northwest with increasing steepness, a similar succession of beds of sandstones and slates was found, with the lowest resting upon Archæan rocks, such as constitute the core of the main ridge.

Thus we found what is manifestly a somewhat shallow syncline, about three miles wide, running parallel with the general range of mountains, and occupied by successive beds of sandstones, conglomerates and slates, bearing a decided resemblance to the lower members of the Cambrian beds, on the N.W. side of the main mountain, though very considerably modified by metamorphism; so much so that I, as well as others formerly regarded this syncline as of Huronian age, and I pointed it out as such to Prof. C. H. Hitchcock some two or three years ago as we passed it on the Richmond & Alleghany train; but the subsequent discovery of a bed of sandstone *in situ*, containing characteristic *Scolithus borings*, settles the question that the beds in question are of Cambrian age.

In confirmation of our conclusion, Mr. H. D. Campbell has traced the Scolithus bed, with its accompanying conglomerate for at least five miles on each side of the river For some distance from the margin of the river, on the Amherst side, the higher members of the series appear to have been removed by denuding agencies; but on the S.W. or Belford side, he found the "Balcony Rock"—the lowest bed of quartzite—well exposed; then, in the next higher sandstone bed, he found abundant traces of Scolithus, corresponding in position and range with what had been found on the other side. Some of the higher peaks a little remote from the river, he found capped with the main Scolithus bed, the upper or typical Potsdam sandstone of this region. We may conclude therefore, that this portion of the Blue Ridge has been formerly spanned by a grand arch, or series of arches, of Cambrian age, upturned perhaps at the time of their upheaval—the broken fragments of which have been carried away, and only the abutments left to tell the story of a great catastrophe.

Washington and Lee University, August, 1884.

SCIENTIFIC INTELLIGENCE.

I. Physics.

1. *Photographing Colored Objects in their Natural Shades.*—Professor H. W. **Vogel** has laid before the Physical Society of Berlin the results of his long continued researches on this subject. It is well known that unnatural pictures of colored objects are generally obtained by photography, the darkest shades of blue appearing white, the brightest tints of yellow and red as black, and so on. Professor Vogel has endeavored to render his plates less sensitive to less refrangible rays by alloying the silver coating with some substance capable of absorbing these rays. He has obtained in eosine, and more especially in its various derivatives, coloring substances which possess merely a broad absorption band in the yellow, and which give the desired results. By mixing these bodies in the right proportion on the dry gelatine plates, the yellow of the colored objects appeared quite clear on the photograph; but the blue was brighter. Thereupon Professor Vogel inserted between the object and the camera a yellow glass, which partially absorbed the blue rays, leaving the yellow unimpaired. In this way photographs can be obtained, in which the green and yellow and to some extent the red portions of colored objects present the same vivid effects as the originals.—*Nature*, June 19, 1884, p. 188. J. T.

2. *Measurement of Magnetic Forces by means of Hydrostatic Pressure.*—G. **Quincke** has shown that electric force produces a pressure upon insulating liquids placed in an electric field. The effect is the production of a tension parallel to the lines of electric force, and of a nearly equal pressure at right angles to the lines of electric force, which are proportional to the square of the electric force at the point of the electric field where the experiment is made, and also proportional to the dielectric constant of the fluid under consideration. He has now extended this investigation to magnetic and diamagnetic fluids placed in magnetic fields. From analogy we should have in this case $\rho = \frac{K_1}{8\pi} H_1^2$ (Maxwell's Electricity and Magnetism, 2d ed., ii, p. 257, § 642), in which H_1 is the magnetic force at the point in question in the magnetic field, and K is what may be called by analogy the diamagnetic constant. The value of this for air is 1. "If the magnetic fluid is bounded by air, the magnetic difference of pressure in the fluid and in the

air may be expressed by a hydrostatic pressure, and thus K_1-1 can be measured." The magnetic fields employed by Quincke varied in strength from 300 c. g. s. to 12,000 c. g. s. The liquids were placed in the magnetic field in a square trough of nickel-plated brass plate, with vertical sides of plate glass and a round iron base, which was placed upon the lower horizontal pole surface of a Ruhmkorff electro-magnet, the upper pole plate being brought within a distance of $1{\cdot}7^{mm}$ to $3{\cdot}3^{mm}$. A central opening in the upper pole surface was connected by means of a thin brass tube with a sulphide of carbon manometer and a long India-rubber tube provided with a tap (Wied. Ann., xix, 1883, p. 719). It was found that under the influence of magnetic force the hydrostatic pressure at the bounding surface of air and the magnetic or diamagnetic fluids, parallel and at right angles to the lines of magnetic force, undergoes the same increase or decrease; and that the resulting pressure is of the same magnitude parallel and at right angles to the lines of magnetic force. The magnetic increase in height was in some cases more than 32^{mm} with magnetic fluids and $-0{\cdot}7^{mm}$ with diamagnetic fluids. Quincke gives a full table of the values of the magnetic effect upon different liquids, and shows that the method adopted might be practically employed to measure the intensity of a magnetic field. He also shows that the superficial tension of a magnetic fluid in contact with air is not sensibly altered in a strong magnetic field. The quantity which G. Wiedemann terms atomic magnetism (Pogg. Ann., cxxvi, 1865, p. 23) can also be calculated from Quincke's results.—*Berliner Sitzungsberichte*, Jan. 17, 1884; *Phil. Mag.*, June, 1884, p. 447–459. J. T.

3. *Production of very low Temperatures.*—M. L. CAILLETET has discovered that formene or Marsh gas can be employed to liquefy oxygen without the employment of mechanical means for lowering the temperature of boiling of the cooling liquid. Formene is easily compressed and cooled in ethylene boiling under atmospheric pressure. In the state of a liquid it is extremely mobile, and in passing to the gaseous state lowers the temperature sufficiently to immediately liquefy oxygen. This method makes liquefication of oxygen a very simple process.—*Comptes Rendus*, p. 1565, No. 26, June 30, 1884. J. T.

4. *Use of the Silver Voltameter for the measurement of the Electric current.*—In a recent communication to the Physical Society, Lord Rayleigh stated that he considered the deposition of silver by a current of electricity the best method of measuring the current in absolute measure. One Ampère deposits 4 grams of silver per hour; a sufficient amount can therefore be obtained in fifteen minutes which can be weighed with accuracy. With very weak currents there is difficulty in weighing the deposits; and with very strong currents the deposits are apt to be irregular. Pure nitrate or pure chlorate of silver give the best results. The cathode of Lord Rayleigh's apparatus is a platinum bowl, the anode a silver sheet wrapped with clean filter paper sealed over

it to keep any loose silver from dropping on the cathode. The anode is immersed in the solution of silver salt; and at the end of several hours a measurement of the weight of silver deposited is made by weighing the bowl cathode in a chemical balance. This process is found preferable to weighing the loss of weight of the anode.—*Nature*, July 17, 1884, p. 283. J. T.

5. *Change of temperature due to Magnetization and Demagnetization.*—M. Bachmetieff has made at the University of Zurich an extensive series of experiments on this subject, the first part of which is now published in the Journal of the Russian Chemical Society (vol. xvi, fasc. 3). He arrives at the conclusion that magnetism irrespective of currents of induction produces changes of temperature in magnetized bodies and that this "magnetic heat" is equal to the product of the magnetic moment by the magnetizing force multiplied by a constant. Its cause must be sought for in purely mechanical forces; and it depends upon the speed of rotation of the molecular magnets.—*Nature*, July 3, 1884, p. 223. J. T.

6. *Radiation of a Swan incandescent lamp at different temperatures.*—H. Schneebeli employed in his investigation the method of Svanberg and Langley. The resistance of the lamp while cold was 80 ohms. The following tables exhibit the results:

No. 1.			No. 2.		
Current strength.	Entire radiation.	Light radiation in candles.	Current strength.	Entire radiation.	Light radiation in candles.
44·5	87·0	0·12	48·0	102·0	0·3
48·8	97·0	0·25	76·2	254·0	5·5
57·0	158·	0·70	94·2	392·0	24·0
67·0	195·	1·85			
75·0	250·	5·4			
88·2	348·	17·5			

For each current strength, J, there exists the following relation, $J^2W=CS$, in which W is the resistance of the carbon at the designated temperature, S the energy emitted by the lamp, and C is a constant. If W, the resistance of the lamp, is constant between 900° and 1500° temperature, one has $\frac{J^2}{S}=$ constant. This is expressed by the following values:

J.	44·5	48·8	57	67·0	75·0	88·2	48·0	76	94·2
$\frac{J^2}{S}$	22·8	24·5	20·7	23·0	22·5	22·4	22·6	22·8	22·6

The resistance of carbon between red heat and white heat appears to be independent of temperature. The absorption coefficient of the glass globes of the lamp appears also to be independent of the temperature between these limits.—*Ann. der Physik und Chemie*, No. 7, 1884, pp. 430, 438. J. T.

7. *The Electrical Exhibition at Philadelphia.*—The Electrical Exhibition which the Franklin Institute is making extensive preparations to hold in Philadelphia, during the months of September and October of the present year, promises to be a large and

representative one. Exhibitions devoted exclusively to electricity and its applications have been held with most pronounced success in Paris, Munich and Vienna, at each of which America participated largely, and carried off her full share of honors. The subject is one which occupies a large share of the public attention; and an exhibition in this country, which shall creditably represent the great progress which the science has made since the period of the Centennial, and which shall especially show how largely the world is indebted to American discovery and invention for the advances that have been made, will not only possess an unusual attractiveness, but if proper use is made of the opportunity, will prove most beneficial as a popular educator. For this reason it is most fitting, that the first electrical exhibition held in America should be undertaken by a scientific body of such assured standing and unquestioned respectability as the Franklin Institute of the State of Pennsylvania.

The buildings, in which the exhibition will be held, occupy several blocks, and are situated at 32d and Lancaster avenue, in West Philadelphia, within a convenient distance from the heart of the city, and readily accessible from all directions by the steam and street railways. The exhibition is announced to open on September 2d, and to close on October 11th. The system of classification which has been approved by the committee having the work in charge is very elaborate, and, in its general features, original. The exhibits will be grouped under the following seven sections: Section I, Production of Electricity; Section II, Electric Conductors; Section III, Measurements; Section IV, Applications of Electricity; Section V, Terrestrial Physics; Section VI, Historical Apparatus; Section VII, Educational and Bibliographical. Each of these sections is subdivided into numerous classes.

The committee charged with the duty of preparing a schedule of the tests to be conducted, of the apparatus and machinery, has prepared and published a code in accordance with which the work shall be carried out, and has invited a large number of eminent specialists in electricity and mechanics to coöperate in the work. These tests will include the steam boilers and engines, as well as the special electrical apparatus and machinery.

The project of the exhibition is international in character, and a considerable number of foreign exhibits will make their appearance. The foreign exhibitors will be principally in the classes devoted to educational apparatus, and instruments of precision for electrical measurements. This country will be represented by all the leading companies, manufacturers and inventors engaged in the field of electricity and magnetism covering of course very completely the subjects of the electric telegraph; electric lighting by the several systems (arc and incandescence); the telephone; microphone; electric signaling systems for railways; electric clocks, time telegraphs and other electric devices for recording or registering at a distance; electricity as applied to mining, naval and military engineering, to light-houses, to musiments, to the transmission of power, to galvanoplasty tallurgy; and a multitude of other applications.

f these exhibits which are being prepared by the lead- anies engaged in electric lighting will be very large, and e in the highest degree instructive. The historical the exhibition will be full; and the collection of the of electricity and magnetism will be an attractive the student and professional man.

lity of the exhibition will also be enhanced by a series r lectures and by a thorough system of labelling, for the the many to whom the exhibit would be otherwise ible.

eeting of the American Association for the Advance- cience will take place in Philadelphia while the exhi- in progress, and many members of the British Associa- ch meets this year in Montreal, have signified their of being present. To this gathering will be added the Institute of Mining Engineers, the American Institute cal Engineers, and other bodies less prominent.

ating this gathering of scientific forces, and with the tilizing them for the advancement of science, the Frank- ute appealed to Congress to authorize the holding of a l Conference of Electricians" to convene in Philadelphia e period of the exhibition, to discuss matters of interest the present state and future progress of the science, and public the results of their deliberations. This project ably acted on by Congress and approved by the Presi- has caused to be announced through the Secretary of appointment of the following gentlemen as members of sion "which may in the name of the United States National Conference of Electricians . . . and have the of the scope and character of the work of the confer- : Professors H. A. Rowland, M. B. Snyder, J. Willard hn Trowbridge, C. A. Young, G. F. Brackett, Dr. W. H. ofessors Simon Newcomb, G. F. Barker, E. J. Houston, sk, Francis C. Van Dyck. The first meeting of this n was held on Thursday, August 7th, in Philadelphia, at f the Franklin Institute, under the chairmanship of Pro- wland. From the scientific eminence of this commission, s of the Conference promise to be of the first importance. ther evidence of the interest which the forthcoming exhibition has attracted, it is worthy of note that the ciety of London has deemed it of sufficient importance t four of its members: Dr. John Hopkinson, Mr. W. H. ord Rayleigh, and Sir William Thomson, to act as its tives.

er exhibition undertaken by private enterprise, has ever to exercise the proper function of an exhibition so n educational institution, and it is to be hoped, that by igent use of its great opportunity, the Franklin Institute will prove itself equal to the task it has set itself to perform, and add fresh laurels to those it has earned in the past. W.

8. *Études pratique sur les Marées fluviales et notamment sur le Mascaret, application aux Travaux de la Partie maritime des Fleuves*, par M. COMOY. 389 pp., large 8vo, with an atlas of ten plates. Paris: 1881 (Gauthier Villars; New York, F. W. Christem).—This work by M. Comoy is a valuable contribution to a difficult and complex, and at the same time, highly interesting subject. The author approaches it from the practical side, through the results of numerous personal observations and published records rather than by means of mathematical analysis. The opening chapters contain a simple discussion of waves of translation and oscillation, after which tidal waves in general are considered, and then the more difficult subject of tidal waves in rivers—all in a clear and satisfactory manner. The chief interest of the volume centers in the discussion of the Mascaret, a phenomenon to the study of which the author has devoted much time and labor. The mascaret is the name given in some parts of France, as on the rivers Garonne and Dordogne, to the peculiar wave which advances up the river something like a wall at the head of the tide; it is a similar phenomenon to the Bore on the Ganges, the Prororoca in the Amazon and the Barre on the Seine. It is a capricious phenomenon on some rivers of a country, varying much in its action, sometimes almost disappearing and again regaining its original intensity. The author discusses this portion of his subject with much thoroughness, going over the views of others as to the cause of the phenomenon and then developing his own on the same subject. The author shows the effect upon the mascaret of the varying conditions, such as depth of river-bed, width of channel, etc.; he also discusses the influence upon the fluvial tides of public works undertaken in the rivers to facilitate navigation. In the final chapter he gives a detailed study of the principal rivers of France in their relation to the tides.

II. GEOLOGY AND MINERALOGY.

1. *Preliminary Paper on the Terminal Moraine of the Second Glacial Epoch;* by T. C. CHAMBERLIN. 110 pp. 4to, with maps and plates. From the 3d Ann. Rep. of the Director of the U. S. Geological Survey, 1881–82.—This important paper by Professor Chamberlin is briefly noticed at page 68 of the last volume of this Journal. It commences with a statement of general principles with regard to the drift, and a description of the materials, their kinds, arrangement and distribution, and then gives details with regard to the structure, forms and geographical arrangement of the "Terminal Moraine of the Second Glacial Epoch."

The relation as to position between this second terminal moraine and the southern limit of the "drift-bearing area," or the extreme limit of proper glacial transportation, is well presented on the p making plate xxviii. The two limits are not separated along islands south of New England. Westward, the extreme limit s the course laid down by Messrs. Cook and Smock for the part it in New Jersey, Lewis, in Pennsylvania, and Wright, in Ohio d Indiana; and farther west it crosses the Mississippi at St. uis, reaches its southernmost point, on the parallel of 38°, along Osage River, and then runs northwestward and northward, to 100 miles west of the Missouri.

The moraine belts referred to the "second glacial epoch," in w York and west of it, lie 50 to 500 miles north of the southern ft limit. They extend southward in "loops" that show the tline of distinct glacier movements, or at least so, where the rainic feature is well defined and it is supported in evidence divergent glacial striation and transportation. The important servations on these moraine loops by Professor Chamberlin ve thrown much light on the glacial phenomena of North nerica. A brief statement of his general results is given him in a paper in this Journal, published in August, 1882, and rt of the details earlier in volume ii of the Reports of the isconsin Geological Survey. In the present report, excellent ps and full descriptions are presented of the wonderful loops de out by him to correspond to a Green Bay and Michigan ke glacier; and also of other morainic loops, such as the Grand averse, the Saginaw, the Maumee or Western Erie, the Scioto d others.

Professor Chamberlin has extended his careful observations stward over New York and the marginal regions of the glacier rther east. He describes loops in western New York; and east these, a Mohawk Valley moraine (making the movement of e ice west of Herkimer to have been westward, while east of ere, eastward); and a Hudson River moraine; and he suggests, om the south-by-west and south-southwest movement in the onnecticut Valley, the idea of a "tendency to minor lobation" that valley. But he remarks as regards eastern New York at he is not ready for any positive opinion.

The writer has given his views as to the Connecticut Valley ice cently in this Journal, and will only add here that he has not t observed in New England any facts that can be referred to a cond glacial epoch, or any morainic deposits away from the ghest mountains that are not a consequence of or dependent on bottom movements in the glacier mass determined largely the forms of the underlying land.

The map of the courses of glacial movements in the Hudson iver valley indicate, if sustained by further observation, that the moved from Albany, in that valley, over the Mt. Washington mmit in southwestern Massachusetts, where the ice (since the mmit is 2,624 feet high and is glacier scratched) had probably height of at least 3,000 feet; and this implies, consequently, at the height of the ice at Albany, forty miles north-northwest, s greater than this—probably 3,500 feet. But, as the striæ north and northeast of Albany have a south-southwest direction a higher ice-summit existed to the north-northeast toward or within the area of Vermont. It seems probable that all the phenomena can be accounted for, by the view, diverging a little from Professor Chamberlin's, that New England with nearly all New York was under one broad lobe of the glacier having its greatest height along or in the vicinity of the Taconic, Green and Adirondack Mountains, and other lands in that direction farther north; that from this axial portion the movements were eastward, southeastward and southwestward—the Catskills, overtopping, as Smock has shown to be probable, the surface of the southwestwardly-moving ice. This conclusion appears to flow from Professor Chamberlin's map, plate XXXIII, and it accords, as far as New England goes, with the writer's published views. The query remains, as to how far the morainic loops of the eastern half of New York may be accounted for on the view of one glacial epoch, and one glacier subdivided *at bottom* by the valley depressions of the underlying land.

Prof. Chamberlin, in speaking of the *Long Island moraine deposits*, expresses his dissent from Mr. Upham's view that the two lines, the northern and southern, (which are distinct along only a portion of the island, and are but five to fifteen miles apart,) correspond to the moraines of the first and second glacial epochs, urging as an objection the great improbability that the two would be so nearly parallel; and he suggests that they are more likely to be parallel morainic lines of one and the same epoch. The writer here adds that he has satisfied himself that the double line of elevation in Long Island was a configuration of the surface that preceded the era of glacial depositions. The underlying sands, gravels and clays, up to a level usually of eighty feet and often greater, are Tertiary (where not Cretaceous), and the subdivisions into high or low regions appear to have existed in these older deposits of Long Island before glacial deposition took place. Over Long Island all the high lands are covered with bowlders, many of large size; but over the lower lands, that at the head of Peconic Bay which separates the higher lands into a northern and southern range, and those of the great bay-like valleys of the north coast, as well as that of the long gradual slope of the south coast from 80 feet to sea-level, bowlders are almost uniformly absent (the cases of slips down the bluff fronts excepted). So complete an absence occurring in the midst of the deposits of a terminal moraine is a striking fact. The writer has found no way to solve the puzzle except by supposing that these low parts were occupied by water when the drift deposition took place; that the stones fell into the water and were afterward covered up by stratified deposits of sand and gravel, for this is the constitution of the deposits of these lower lands of the island. The white and yellow Tertiary clays, white sands and gravel are beautifully displayed at Stuart's beds near the middle of the island west of Hicksville about 80 feet above the sea. Further, I was led to

nclude that the Peconic Bay depression cut through the Ter-
ry, and the deep depressions occupied by the broad and many-
ned bays of the north coasts (which are of wonderful extent for
land of so little height having no rocks in sight) were part of
e results of under-glacier streams of the Glacial era, before gla-
l deposition had made much progress; that these were thus
de deep, and afterward became submerged in the opening of
e Champlain period, the era of subsidence, melting and deposi-
n.

The writer may here state also that in 1873, in his paper on the
acial and Champlain eras in New England (this Journal, v,
0), he makes the suggestion that the coarse drift of Long
and was probable evidence of *a terminal moraine deposit from*
e melting southern edge of the retreating glacier. It is still
ue that nobody knows whether the glacier may not have exten-
d miles outside of Long Island when at its farthest limit, a
ew the same paper favors. The principal objection to it comes
om the now known fact, that the terminal moraine of New
ersey is nearly in a line with the southern coast of Long Island.

J. D. D.

2. *Pennsylvania Geological Survey. Report Z: on the Ter-*
inal Moraine in Pennsylvania and Western New York; by
L C. Lewis. 300 pp. 8vo, with maps, photographic views and
ections. Harrisburg, 1884.—This report has special interest
ecause of the length, form and features of the "terminal mo-
aine" which crosses the State of Pennsylvania and also because
f the thoroughness of the survey. In much of the work Profes-
or Lewis was associated with Professor G. F. Wright and the
eport is partly a result of their combined labors. The glacial
henomena are described in detail for each of the glaciated
ounties. The results prove, as has already been announced in
his Journal, that the glaciated part of Pennsylvania occupies two
reat areas, a large northeastern, and a very small northwestern, a
ct due to the crossing by the terminal moraine of the north
oundary of the State into Cattaraugus County, New York. The
erminal moraine is described as a line of drift hills made "mainly
f glaciated material," but as "often inconspicuous;" as, in many
arts a succession of conical hummocks with kettle-holes, the latter
ometimes the sites of ponds; as frequently a limit between a
ore northern region of many lakes, and a more southern of no
kes, the lakes owing their existence mostly to the damming
ffect of the drift deposits. The mean width is about a mile.
arge stones and bowlders are abundant—while there are compara-
vely few north of the line. As the character and height of the
untry passed over by the moraine line is of much interest, we cite
ere the general account of its course, from page 47 to 49 of the
port.

"Beginning in Northampton county, a mile below Belvidere,
appears through the stratified drift as low gravel hills. These,
inding up over the slate hills to the west, are soon developed

into an accumulation of typical *till*, holding kettle-holes and filled with bowlders. Bending in a great curve first westward and then northward it reaches the base of the Kittatinny Mountain three miles east of the Wind Gap. Ascending to the top of the Kittatinny Mountain (1600 feet above tide) the moraine crosses it, being well shown upon the very summit, and, entering Monroe County, crosses the great valley between the Kittatinny and the Pocono, enclosing in its course several moraine lakes. Having crossed this valley and reached the base of the Pocono escarpment it swings sharply back and around Pocono Knob. Immediately afterward it ascends the steep face of the mountain to the wide plateau on top, 2100 feet above the sea. Crossing the center of Kidder township, Carbon County, it reaches the gorge of the Lehigh River about ten miles north of Mauch Chunk, which it crosses at Hickory run. Without swerving from its general northwestern course it crosses the Hell-Kitchen Mountain, Cunningham valley, and Nescopec Mountain, in Luzerne County, and descends to the valley of the east branch of the Susquehanna River, which it crosses at Beach Haven. Here heaps of drift have been washed down the river into terraces. In Columbia County, after following awhile the base of Lee's Mountain it ascends to the summit (1350 feet); crosses the high red shale valley, and the crest of Huntingdon Mountain; and then descends the north slope of that mountain to the broad undulating valley of Fishing creek. Taking a northerly course it follows up the *east* bank of Fishing creek to the North or Allegheny Mountain.

The summit of the Alleghenies in Sullivan County is covered with glacial striæ and other marks of glaciation. In Lycoming County the moraine passes westward along the base of the mountain, crossing Muncy and Loyalsock creeks, and then, near the village of Loyalsock, turns at right angles and ascends to the highlands. Having reached the summit of the Alleghenies (over 2000 feet above the sea) it crosses the picturesque cañon of Lycoming creek, and passing west through a wild, wooded region nearly as far as Pine creek, it takes a nearly straight northwestward course through the southwest corner of Tioga County and the northwest part of Potter. On the high ground of Potter County it crosses a great continental water-shed from which the waters flow into the gulf of Mexico, Lake Ontario and Chesapeake Bay. Here the moraine is finely shown at an elevation higher than anywhere else in the United States, 2580 feet above tide.

The line of the moraine now enters the State of New York in the southwest corner of Allegheny County. Running still northwest and entering Cattaraugus County, it twice crosses the winding course of the Allegheny river, east and west of Olean; then, trending to a point five miles north of Salamanca, in latitude 42° 15′, it suffers a remarkable change of direction. Turning at right angles to its former course it passes southwest through the southeast corner of Chautauqua County, and keeping approximately parallel to the Allegheny river, reënters Pennsylvania in Pine Grove township, Warren County.

It crosses the Conewango River seven miles north of Warren, forming immense accumulations in the valley of the river. Then, trending west in Warren County (still at a general elevation of nearly 2000 feet above the sea) the moraine crosses one gorge after another, and forms a line separating not only the glaciated from the non-glaciated regions, but also the cultivated from the uncultivated and densely wooded regions." After crossing Crawford, Venango and Butler Counties, the southeast corner of Lawrence and the northwest of Beaver County, it "crosses the Ohio State line in the middle of Darlington township, thirteen miles north of the Ohio River, in latitude 40° 50′. The moraine thus leaves Pennsylvania at *precisely the latitude* at which it entered the State."

"The total length of the moraine is about 400 miles. It crosses the Delaware at an elevation of 250, the Allegheny at an elevation of 1425, and the Beaver at 800 feet above the sea (225 feet above Lake Erie); but upon the high lands of Potter County it rests on ground nearly 2600 feet above tide and its surface must have been about 3000 feet."

The thickness of the till is stated to vary from a mere sprinkling of bowlders to 100 feet or more; it is even 200 feet deep in many parts of northwestern Pennsylvania, while in eastern, it is generally thin.

Mr. Lewis gives for the usual limit of transport of bowlders in Pennsylvania 10 to 20 miles. The thickness of the ice at the terminal edge in *some valleys* is estimated at about 700 feet, and five miles back 1000 feet; but where the edge of the ice was diagonal to the trend of the mountains, the thickness was in some cases greater, as near Stroudsburg, 8 miles back from the limit, it must have been 2000 feet. Scratches and a large bowlder on Penobscot Knob, 2200 feet, make the probable height of the ice over the knob 2500 feet; and this was only 8 miles north of the "terminal moraine." In his introductory letter accompanying Mr. Lewis's report, Professor Lesley makes the height over the Kittatinny Mountain, in eastern Pennsylvania, at *the least* 600 feet, and 1800 feet over Cherry Valley to the west. Examples are mentioned of large bowlders resting on elevations more than 1000 feet above their source; two such on the Kittatinny Mountain, one of them twenty feet in length; a class of facts known to be well illustrated by bowlders on Katahdin in Maine, and others carried from Canaan into Goshen, Connecticut; showing that the bottom ice, as it was pressed forward in consequence of the upper surface of the glacier rising to a higher level to the northward, moved up the encountered slope carrying its gathered load of stones.

The direction of the glacial striæ over the eastern ice-region of Pennsylvania is described as southwesterly, while the same over the northwestern, is southeasterly.

The most remarkable feature brought out by the investigations is the bending of the moraine northwestward in crossing the state of Pennsylvania, and then its bending around in Cattaraugus County, New York, for another southward extension. Consequently the glacier between Cape Cod and the Boston headlands, on the east and Cattaraugus County on the west, had an arched front, the chord of which arc along latitude 42° 15′ was nearly 500 miles long, and the versed sine, about 120 miles. It was the southern front of the portion of the great ice mass which covered New England and New York, and the regions to the northeastward, from whose higher portions the movement of the ice was southeastward and southwestward. Professor Lewis's report is fully illustrated by maps and views.

J. D. D.

3. *Geological Survey of Pennsylvania.*—Besides the volume by Professor H. C. Lewis, above noticed, the survey has issued recently also the following reports:

Report D3, Vol. II, Part I: The Geology of the South Mountain belt of Berks County; by E. V. D'Invilliers, with maps and plates, and an atlas, 1883.

Atlas to D4, Vol. I and II.

Report H7: a revision of the Bituminous Coal Measures of Clearfield County; by H. M. Chance. 198 pp. 8vo, with maps and sections.

Atlas of the Western Middle Anthracite field to illustrate Report AA, Part I, Chas. A. Ashburner, Geologist-in-charge.

4. *Palæontology of the State of New York*, vol. v, Part I, *Lamellibranchiata.* I, Text and Plates, containing *descriptions and figures of the Monomyaria of the Upper Helderberg, Hamilton and Chemung Groups;* by JAMES HALL, State Geologist. 268 pp. Albany, 1884.—The volume of text now issued was preceded a year and a half since by a volume of 80 plates, which is briefly noticed on page 391 of volume xxv of this Journal (May, 1883). To these plates 12 more are now added, Nos. 81 to 92. The species described are those belonging to the families *Pectenidæ, Pterinidæ, Aviculidæ, Ambonychidæ* and *Mytilidæ.* The Lamellibranchiates discovered in the New York Paleozoic now number about 600, and 500 are from the groups above the Oriskany sandstone. Professor Hall recognizes among the inequivalve species, under Pectenidæ, 5 genera, the Pterinidæ, 3 genera, the Aviculidæ, 7 genera; and among the equivalve species, under Ambonychidæ, 1 genus (Byssopteria), and under the Mytilidæ, 4 genera; and fifteen of the new genera are instituted by him. The volume opens with a synopsis of the classification and brief descriptions of the genera. The plates are most excellent, and the work is a rich contribution to Zoological science as well as American Paleontology.

5. *Octahedrite as an alteration-product of Titanite.*—Mr. J. S. DILLER has made some interesting observations on the occurrence of octahedrite (anatase) as a product of the alteration of titanite in the biotite-amphibole-granite of the Troas. After describing the unaltered rock in regard to the more conspicuous char-

acters, the author goes on to mention some highly altered varieties observed near the village of Tavacly. In this altered granite the feldspar has been changed either into a mass of minute highly refracting scales, or to a fine granular mass with weak aggregate-polarization; the mica and hornblende have completely disappeared and in their place there is a greenish fibrous substance with carbonates and numerous crystals of a yellow mineral not found in the fresh rock; the zircon is unchanged, but the titanite has also completely disappeared. It is to the last change that the greatest interest is attached. The mineral which has taken the place of the titanite has a wine-yellow to honey-yellow color and shows under the microscope quadratic and rhombic sections; the former isotropic, the latter strongly doubly-refracting with the extinction-directions parallel to the diagonals. The crystalline system is thus found to be tetragonal, the form that of a square pyramid. Cleavage parallel to the base and to the pyramid was also observed. By use of the Sonstadt solution the specific gravity was found to be between 3·6 and 4·5. Also under the microscope the terminal pyramidal angle was determined from the sections to be 98° 24′, and the basal edge of the rhombic sections 136° 16′. These angles, as also the characters previously given, agree with those of octahedrite; moreover, the presence of titanium was also proved by chemical means, thus leaving no doubt as to the identity of the mineral. These observations are of interest in view of the often observed alteration of titanite and titanic iron, and the author regards that the production of octahedrite is a common result, though frequently overlooked on account of the minuteness of the crystals.—*Jahrb. Min.*, 1883.

6. *Chlorophane from Amelia County, Virginia.*—Mr. GEORGE F. KUNZ has recently presented to the New York Academy of Sciences a note on some specimens of the variety of fluorite called chlorophane, from Amelia County, Va.,—the locality which has furnished the remarkable specimens of microlite and monazite. The occurrence of fluorite at the locality has been described by Fontaine (this Journal, xxv, 333), who also noted the brilliancy of the phosphorescent light which it gives out at a low temperature. Mr. Kunz states that, while handling in the dark a few specimens of this mineral, phosphorescence resulted by the slightest attrition of the specimens, either one with another, or with a ail or hard substance. An examination of ordinary fluorite from everal localities, did not show this property of phosphorescence y attrition, while it appeared conspicuously in specimens of hlorophane from Amelia County, Va., and North Chatham, N. H.; consequently appears to be a distinguishing character of chlorohane. Pallas mentions a specimen from Siberia, of a pale violet olor, which gave out a white light merely by the heat of the and; by the heat of boiling water, it gave a green light, and when n a live coal, a bright emerald green light that might be diserned from a distance. In a dark room at a temperature of bout 80° Fahr. the Amelia County mineral shows a white lum-

inous light, which by the warmth of the hand is intensified; when placed in boiling water it becomes green, and on a heated iron plate it becomes an intense emerald green. Most of the material is more or less flawed, so as to render it very friable to the touch; this variety seems to phosphoresce at even a lower temperature than the more compact form, and is either a light green or a yellowish green.

7. *Brief notices of some recently described Minerals.*—MANGANOSTIBIITE, AIMATOLITE, and AIMAFIBRITE are three new minerals from the Moss mines in Nordmark, Sweden, recently described by L. I. Igelström (Geol. För. Förh., vii, 210 et seq., 1884).—*Manganostibiite* occurs with other manganesian minerals in the crystalline limestone enclosed in the ordinary granulite of Sweden. It appears as small black grains, probably belonging to the orthorhombic system. It is compact, with difficult cleavage and greasy luster; the powder is brownish. It is infusible before the blowpipe, and perfectly soluble in hydrochloric acid. An analysis afforded:—

Sb_2O_5	As_2O_5	MnO	FeO	CaO	MgO
24·09	7·44	55·77	5·00	4·62	3·00=99·92

for which the formula $5MnO, (Sb, As)_2O_5$ is calculated.

Aimatolite (from αἱματοειδής, color of blood—the name should properly be hæmatolite or hematolite). Also occurs in cavities in the limestones in small crystals of rhombohedral form with basal cleavage. The color is transparent and of a fine red like that of precious garnet, the powder is brick red. An analysis gave:

As_2O_5	MnO	FeO	MgO	CaO	H_2O
25·70	34·55	13·05	8·10	2·52	16·08=100·00

for which the formula $2(Mn_3As_2O_8)+8MnH_2O_2+6H_2O$ is calculated.

Aimafibrite (hemafibrite) occurs in a mixture of magnetite and serpentine. It forms spheres a centimeter in diameter, which are radiated and fibrous in structure, the form belonging, according to observations by Bertrand, to the orthorhombic system. The color is blood-red, resembling the mineral just described. An analysis gave:—

As_2O_5	MnO	FeO	MgO	CaO	H_2O
29·94	46·98	4·65	2·00	1·50	14·93=100

for which the formula $2Mn_3As_2O_8+7MnH_2O_2+6H_2O$ is calculated. Hematolite and hemafibrite are very near each other in composition, and they are also near to the allaktite of A. Sjögren, recently described from the same locality (this Journal, xxvii, 494).

Utahite is a supposed new iron sulphate from Eureka Hill, Juab County, Utah, described by Arzruni. It forms a yellow-brown crystalline crust on quartzite. The individual crystals are very minute; their form is a hexagonal prism with rhombohedral planes on the alternate angles. The cleavage is prismatic; the luster silky. An analysis by M. Damour gave:—

SO_3	As_2O_5	Fe_2O_3	H_2O
28·45	3·19	58·82	9·35=99·81

for which the formula $3Fe_2O_3$, $3SO_3+4H_2O$ is calculated, which separates it more or less clearly from the other known iron sulphates.—*Bull. Soc. Min.*, vii, 126, 1884.

GOYAZITE.—M. Damour has given the name goyazite to a phosphate of alumina and lime which he has identified among same minerals received from the diamond sands of the province of Minas Geraës in Brazil. It is found in small rounded grains, one to five millimeters in diameter. They are more or less transparent, of a yellow white color; they show one cleavage. The hardness is that of apatite and the specific gravity 3·26. An analysis gave:—

P_2O_5	Al_2O_3	CaO	H_2O
14·87	50·66	17·33	16·67=99·53

For this the formula P_2O_5, $5Al_2O_3$, $3CaO+9H_2O$ is given, which requires: P_2O_5 14·38, Al_2O_3 52·19, CaO 17·02, H_2O 16·41=100. —*Bull. Soc. Min.*, vii, 204, 1884.

III. BOTANY AND ZOOLOGY.

1. GRAY'S *Synoptical Flora of North America*, Part II, is at length issued. It comprises the Gamopetalous orders from *Caprifoliaceæ* to *Compositæ* inclusive, thus concluding the Gamopetalous orders. An enumeration, which precedes the full index, indicates that of the *Caprifoliaceæ* there are 8 genera and 47 species; of *Rubiaceæ* 26 genera and 86 species; of *Valerianaceæ* 2 genera and 22 species; of *Dipsacaceæ* 1 genus and 2 species (naturalized); of *Compositæ* 237 genera and 1610 species. The part runs to 474 pages, or 72 more than in Part I. Yet it is less thick than its predecessor, the paper, though excellent, being thinner. It bears the imprint of Ivison, Blakeman & Taylor, New York, Wm. Wesley and Trübner & Co., London, and O. Weigel, Leipsic. It will also be sent by mail, postpaid to any part of the United States and Canada, by addressing The Curator of the Herbarium, Cambridge, and enclosing the price ($5), as a convenience to distant botanists.

2. *The Orchids of New England: a popular Monograph;* by HENRY BALDWIN. New York: John Wiley & Sons. 1884. pp. 158, 8vo.—Botanists will not find in this volume a monograph of the Orchideæ of New England in their sense of the term. It is, as the title declares, "a popular monograph," a collection of what has been ascertained and written about our Orchids, by one who has paid particular attention to them, and who has recorded many observations of his own upon their habits, their appearance, and their structure, and some upon their insect-fertilization. But upon this subject, in which very much remains to be done, the author has generally preferred to quote. Having entered upon this interesting line of observation, Mr. Baldwin ought not to stop upon the threshold. There is perhaps not one of our

species that has been sufficiently studied in this regard; and the study may be expected to render a second edition more scientifically and independently valuable, without any sacrifice of popularity. The figures might be better, and they would have been made more telling by neat magnified views of the parts. A. G.

3. *The Student's Flora of the British Islands;* by SIR JOSEPH D. HOOKER. Third Edition. London: Macmillan & Co., 1884. —This third edition gives evidence that the great popularity of this well-planned and well-executed Flora continues undiminished. It is not increased in size; the changes, though not inconsiderable in the treatment of certain groups and species, are not striking; but the revision has been evidently been critical. *Subspecies* are more largely adopted: varieties accordingly play a diminished part,—a fair compromise between the schools of narrow and wide limitation of species, and perhaps a necessity in the long-worked floras of Europe. "Characters concerned in the process of fertilization" are also introduced into this edition. A good beginning, but, to serve their purpose in a popular flora, more particularity would seem to be needed, and the dichogamy which is attended by change in position (as in cases like *Scrophularia*, *Epilobium angustifolium*, &c.) might well be indicated. The different modifications of a peculiar structure in *Campanula* (of which only a rarer form is mentioned in the generic character) might well come into the description of the species or sections. The use of the term *homogamous* for flowers which are neither proterandrous nor proterogynous (i. e. not dichogamous) is unfortunate (though it was introduced by C. C. Sprengel), being a term of common use for quite another thing, from Lessing down to the new Genera Plantarum. If A. W. Bennett's term of *synacmy* does not well take an English adjective form, why not use the ready-made and obviously apt word synchronous? A. G.

4. *Hypopitys or Hypopithys?*—As the work above noticed and the recent Genera Plantarum adopt the latter orthography, and DeCandolle the former, it is worth while to determine, if possible, which best conforms to the rules of nomenclature. There is no question that the former is orthographically correct and that the latter is a falsified form. The older botanists on the Continent, not pronouncing the *h* in *th*, seem to have thrust it into various words according to their fancy, probably thinking that a silent letter could do no harm. If we turn to Linnæus, to the classical Endlicher, and to Bentham and Hooker, we should infer that they had done so in the present instance. But we should be wrong. Although Linnæus (who did not adopt the genus) cites "Orobanche quæ Hypopithys dici potest" from Bauhin, and "O. Hypopithys lutea" from Mentzel, in both these authors the name is *Hypopitys*. So far as we know, the adulteration of the word was the work of Linnæus, in the Species Plantarum, and it can be shown to be accidental. For the genus was founded and illustrated by Dillenius, in 1719, as *Hypopitys* (not *Hypopithys*, as Endlicher cites it); and, in referring it to *Monotropa*, Linnæus in

:ry edition of his Genera Plantarum, writes "*Hypopitys*, Dill.,")wing that he had no intention of altering the form of the word. e may therefore conclude that Jussieu and DeCandolle and :ir successors have followed the rule of priority as well as the ıse of the word in writing (not *Hypopi'thys*) but *Hypo'pitys*.

A. G.

5. *The structure and function of Lenticels.*—Heinrich Kle- hn confirms Stahl's description of the minute anatomy of these gans, and shows by experiments in winter (similar to those by ıberlandt in summer), that they aid in the transfer of gases and ıeous vapor. He further shows that in some shrubs devoid of ticels, rifts in the bark, connecting with the intercellular spaces, ve the same purpose.—*Ber. d. deutsch. bot. Gesellsch.*, I, ii, 113.

G. L. G.

3. *The microchemical detection of Nitrates and Nitrites in ants* is possible by the reagent suggested by Wagner, viz: phenylamin. Molisch uses a one per cent, or a one pro mille ution in pure sulphuric acid, applying this to dry sections. If her of the salts above named is present, a deep blue coloration pears, which soon changes to brownish yellow. Brucin in about : same strength is nearly as sensitive a test, producing a tran- ut red or reddish-yellow color. Molisch employs this method o for approximate determination of the amounts of the salts :sent, and finds that the percentage decreases from below up- rd in the plant.—*Ber. der deutsch. bot. Gesellschaft*, i, 150.

G. L. G.

7. *On the structure and growth of Palms.*—Branner gives in : Proceedings of the American Phil. Soc., April 18, 1884, some eresting results of original and apparently careful studies of the ›de of growth of many palms. The essential points of differ- :e between these results and those obtained by other observers ate to the development of the fronds. "The fronds are devel- :d in connection with the *central* bundles in the phyllophore. regard to the origin of the bundles it is sufficient at present to y that they originate at the apex of the phyllophore, and are veloped in it, with it, and as a part of it. Von Mohl and ırbel maintain that these bundles grow up into the phyllophore; ıudichaud that they grow downward from it, from the frond .ses; Von Martius, that they grow both up and down, while I aintain that they are perfected in all directions at the same me, though the lateral growth continues to a certain extent fter the longitudinal growth has ceased, and that they can no ıore be said to grow upward or downward than it can be said f the bones of the body that they grow outward into the limbs. t is true that the general lengthening of the bundles takes place t the superior end, but there is a growth beside this. At the rst appearance of the fronds at the apex of the phyllophore the bro-vascular bundles are already connected with them, and just s intimately as they are in the perfectly developed frond. The ıternodes at this point are very short, but the bundles are the

same in number, and have exactly the same connections, directions and relation to each other that they have in later life. But in the perfected frond we find them larger, longer and harder, and in the perfect stem the internodes are longer, the stem and bundles larger, while the whole plant has grown both longitudinally and laterally." G. L. G.

8. *On the Physiological significance of Water-glands and Nectaries;* by WALTER GARDINER. (Proceedings of the Cambridge Philosophical Society, Nov. 12, 1883.)—These Water-glands are peculiar structures, consisting of modified parenchyma-cells, which occur at the end of fibro-vascular bundles, are protected by epidermis, and communicate with the exterior through one or more water-pores. The cells in these glands are rich in protoplasm but are devoid of chlorophyll. Between the ducts of the bundle and the cells of the gland, there are numerous tracheids which form a transition from one to the other form of tissue.

The exudation from the glands consists in most cases of nearly pure water as in Fuchsia, or of saline solutions, as in many of the Saxifragaceæ. The amount of liquid secreted by these glands has been shown by Sachs to be dependent on root-pressure, and to be greatest at the period of minimum transpiration. Substituting the pressure of a column of mercury for root-pressure, Moll confirmed the results obtained by Sachs. Volkens holds that these glands constitute a mechanism of the nature of a safety valve to relieve too great hydrostatic pressure in the plant, and that where such glands with pores are not present, the office is performed by slightly modified stomata. At this point Gardiner takes up the subject, substantially confirming the results of the others, and adding notes relative to the differences between these glands as they occur in monocotyledons and dicotyledons. No gradual stages between them can be detected as yet, by comparative study, and this gives some support to the view that these groups of plants have been regarded as early branches from a common ancestor, and that there is not a gradual ascent from one group to the other. Gardiner further calls attention to the fact, but lays no special stress upon it, that whereas dicotyledons are typical land-plants, the reverse is true of monocotyledons. Even the apparent exceptions to this broad statement can be partly explained away, such orders as Gramineæ, Aroideæ, and Orchidaceæ, needing for their growth a plentiful supply of moisture. Now we have in monocotyledons glands of very simple structure, and here there is little or no resistance put in between the vascular bundle and the free surface. In dicotyledons there are well developed glands in some plants like Callitriche, where we should suppose they cannot possibly be needed. In the glands of dicotyledons there is a very pronounced resistance to the escape of water, and a greater root-pressure is required to bring about exudation. The constituent cells of the plant-tissue are also rendered more turgid in consequence of the increased pressure, and the water is, to speak, parted with less freely. In monocotyledons, where e supply of water is fairly constant, these special precautions r economizing the water supply are apparently not taken.

Of nectaries the author takes substantially the view of Sachs, amely, that their activity is dependent upon the activity of the ectar-cells themselves, and is independent of root-pressure. His iews conflict with those of Wilson, who attributes the activity o osmosis. Wilson based his conclusions upon the passage of ater through the cuticular membrane of leaves when there is laced thereon any substance which can cause osmosis, and the act that the passage ceases wholly when the substance is withrawn. But Wilson, at any rate, does not explain the exudation f the nectar required to start the osmotic apparatus of the gland. Moreover, Gardiner objects to the use of a strong solution of ugar by Wilson in his experiments, since nectar in some cases ontains only one per cent of sugar. He quotes from Sachs the tatement, that the secreting cells "absorb water (containing ubstances in solution) with great force on one side and exude it n the other," and this solely by their own living activity. The rand period of such activity may be and probably is of short uration, and the further exudation of nectar may be occasioned n the way that Wilson pointed out, namely, by simple osmosis. he paper by Gardiner is accompanied by an excellent set of figres illustrating the structure of the water-gland of *Saxifraga rustata.* G. L. G.

9. *Respiration and Transpiration of Fungi.*—The following onclusions have been reached by BONNIER and MANGIN (Annales es Sc. Nat., Mar. 1884), after a series of carefully conducted xperiments with apparatus of novel construction. 1. Respiration s increased by elevation of temperature, but there is no optimum. . Diffused light retards it. 3. The more refrangible rays of ght are most efficient in respiration. 4. The rate increases with creased moisture in the air. The ratio of the amount of caronic acid evolved to that of the oxygen absorbed varies in diferent species but is less than unity, but for the same species does ot vary with pressure. The relation is constant under all temeratures. As regards transpiration, the following results are ecorded: Elevation of temperature augments the rate; and so oes diffused light, but increased moisture in the air diminishes he rate. G. L. G.

10. *The Principles of Zoogeography;* by THEODORE GILL. 40 p. 8vo. (Proc. Biolog. Soc. of Washington, 1884.)—In this aper the author considers the subject of geographical distribuion both for the land and oceans. Under the latter head Dr. ill arrives at five *primary* marine regions: the *Arctalian* or rctic realm, not well defined in southern limit, but having ts limiting isocryme coinciding nearly with Cape Cod on the astern coast of America, and the Straits of Fuca on the western; 2), the *Pararctalian*, or north temperate realm, including the arious coast regions between the isocrymes of 44° and 68° F.;

(3), the *Tropicalian*, or Tropical realm, between the isocrymes of 68° F. north and south of the equator, or the Torrid zone or Coral reef seas of Dana. (4.) The *Notalian*, or south temperate realm, and extending, "provisionally," between the southern isocrymes of 68° and 44° F.; and (5) the *Antarcticalian* realm, or Antarctic realm. The above pertain to surface or shallow-water regions. Dr. Gill names the deep-water region, the Bassalian realm, putting the whole in one division, though recent investigations apparently point to at least two.

The author concludes from his survey of the subject, that "freshwater types are the best indicators of the early relations of respective regions;" "the flying, and especially migratory, types are most accordant with the actual relations of land areas;" "temperature is a prime factor, and land a secondary, in the distribution of marine animals." The important factor as regards marine life, light, well set forth by Fuchs, is not recognized.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Earthquake in the Middle and Eastern States, August* 10, 1884.—On Sunday, August 10, between seven and eight minutes after 2 P. M. the Middle and Eastern States experienced a decided earthquake shock, more severe and extensive than has occurred in the region for some years.

The area affected extends along the coast from Washington, D. C., and Baltimore, Md., to Portland, Me., and Burlington, Vt., and on the west may be bounded by a nearly straight line from Burlington to Harrisburg, Pa. The intensity was greatest in the vicinity of New York City, which is also about the center of the district affected. It nowhere did any damage beyond breaking crockery and occasionally cracking a house wall. No bodily injury was caused, although it is stated that one or two deaths resulted from the mental effect of fright upon persons in feeble health. The time was very near 14h. 7¼m. Several close time observations have been reported, but it is not yet possible to say whether they indicate a progress of the wave in any particular direction. So far as yet compared, the reports seem to point to the formation of a fault in the geological strata somewhere in the neighborhood of New York Bay, as the probable origin of the vibration.

A fuller notice may be expected in a later issue. C. G. R.

ERRATA.—Article by Professor Langley, on page 171, line 3 from top, the formula $(Aa^2 = Bb^2) - (Aa^3 - Bb^3) >$, should read $(Aa^2 + Bb^2) - (Aa^3 + Bb^3) >$.

Article by Mr. S. W. Ford, on the age of the rocks in the vicinity of Schodack Landing: on page 206, the last sentence of the note should read: It is possible therefore that the two groups here come into contact, etc.; and on page 270, 12th line from the foot, the name Honstein should be Hauenstein. In Professor Campbell's article, p. 222, 25th line from foot, three should be two.

THE

MERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

XXXI.—*On the Duration of Color Impressions upon the Retina;* by EDWARD L. NICHOLS, Ph.D.

at the Montreal meeting of the American Association for the Advancement of Science.]

is now more than half a century since the publication of au's well known researches upon persistence of vision.* In xperiments the velocity was determined at which a revolv- disk with alternate black and white sectors began to nt a homogeneous surface to the eye; and this rate was 1 as the measure of the duration of the image formed upon etina by the bright parts of the disk. Upon substituting yellow and blue sectors for the white ones, Plateau found the velocity necessary to this appearance of homogeneity not always the same, being greatest when yellow was nated with black upon the rotating disk, and least in the in which the white sectors were replaced by blue ones.

is discovery—that the duration of the impression made the retina by light depends upon the composition of the -became the basis of Plateau's theory of retinal after- es. It has found a partial confirmation in some experi- s by Emdmann,† and has been very generally accepted by writers on Physiological Optics; and yet after fifty years knowledge of the manner in which the duration of the

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issertation sur quelques propriétés des impressions produits par la lumière organe de la vue. Liege, 1829.

mdmann, Poggendorff's Annalen, xci.

retinal image varies with the wave-length of the impinging ray remains in the condition in which Plateau left it. The results of his measurements are given in the following table:

Duration of color-impressions according to Plateau.

Color of the alternate sectors.	Total duration of the image.	Undimmed duration of the image.
White,	0·35 seconds.	0·00796 seconds.
Yellow,	0·35 "	0·00798 "
Red,	0·34 "	0·00966 "
Blue,	0·32 "	0·01229 "

The total duration of the image was determined from the slowest rotation which would entirely blur the black sectors of the revolving disk. The time during which the image remained undimmed was calculated from the velocity necessary to give the face of the disk a uniform tint.

Emdmann found the duration of the images to be:

White =0·25′ Red=0·24′
Yellow=0·27′ Blue=0·22′ to 0·29′

These values probably refer to the total duration. Helmholtz* found the undimmed duration of the image when the disk was illuminated by lamp-light to be $\frac{1}{48}$ of a second, by moon-light $\frac{1}{10}$ of a second.

Deeming this phenomenon worthy of further study, the writer has determined, by a modification of the method of Plateau, the persistence of the retinal image as a function of the wave-length of the ray producing it. The measure of the duration of the image, adopted in the experiments to be described, was the longest interval which could be allowed to occur between successive exposures of the retina without interfering with apparent continuity of vision. An ordinary one-prism spectroscope† was so placed as to give a fairly pure spectrum of a beam of diffuse white daylight, the Fraunhofer's lines being well defined. A black disk 240^{mm} in diameter, with four narrow open sectors 5^{mm} each in width, was rotated before the slit of the spectroscope at the rate of two or three revolutions per second. The spectrum of the intermittent ray thus formed presented a very curious appearance. In the extreme red, one could observe but little change of luminosity as each black sector intercepted the light, but toward the center of the spectrum the perturbation became more and more marked, until in the region just beyond the D line there was simply a flash of light at the passage of each open sector, followed by an interval of darkness of noticeable length. Toward the violet the disturbance decreased again, until near the end of the visible spectrum the interruption could no longer be detected. This preliminary observation showed in a most striking manner how differently the various portions of the spectrum affect the eye. It only remained to determine the velocity of the disk at which each spectral region appeared entirely persistent and to calculate therefrom, as Plateau had done in the case of his parti-colored disks, the duration of the corresponding retinal image.

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* Helmholtz, Handbuch der physiologischen Optik, p. 372.

† Professor Rood, in "Modern Chromatics," a treatise to which the writer owes much, has proposed the use of the spectroscope and revolving disk for the study of the duration of retinal images. He says (p. 206). "Dr. Wolcott Gibbs suggested to the author a method which would probably solve this problem in a satisfactory manner, and which is about as follows: With the aid of a spectroscope, a diffraction spectrum is to be presented to the eye in the form of a series of contiguous colored bands, this division into bands being effected by a suitable diaphragm placed in the eye-piece of the instrument. In front of the slit of the spectroscope, a revolving disk with one or more openings should allow the light to enter the instrument; and by carefully regulating the velocity of rotation it would be possible to seize the exact moment when one or more bands ceased to flicker and presented a steady uniform appearance. This observation would give correctly the interval during which the impression remained with undiminished strength on the eye, in the case of the selected color."

The portions of the spectrum chosen for comparison were situated as follows:

Spectral region.	Wave-length in ten-millionths of a millimeter.
Red	7420
Orange	6463
Yellow	6025
Green	5415
Blue	4784
Violet	4382

A diaphragm in the eye-piece of the spectroscope enabled the observer to exclude, during the course of each experiment, all parts of the spectrum not under observation.

It was found by experience that the lowest velocity producing continuity of vision could be best determined by taking advantage of the following phenomenon. The transition from a broken to a persistent retinal image is marked by the appearance of a peculiar blur or shadow in the center of the field of view. At a certain velocity of the disk, just as the image begins to lose its definitely intermittent character, this shadow always appears; fading at a slightly higher rate of rotation to give place to a field of unbroken illumination. The velocity corresponding to its disappearance was accordingly adopted as the best measure of the duration of the image formed by the light from the different parts of the spectrum. The first attempt to carry out the comparison of the images produced by different wave-lengths showed that the time to be measured, "the time of apparent constancy" as Plateau terms it, fluctuated through a very wide range, changing with the intensity of the light and with the condition of the observer's eye. 1 variations due to the change of sensitiveness of the eye were marked and so rapid that any attempt to compare different p tions of an extended series of measurements had to be ab doned. The increased accuracy to be derived from a large nu ber of readings was more than overbalanced by the errors due variations in the condition of the retina. By running rapi through the spectrum, taking a single measurement in ea region, it was found possible to obtain series of readings duri the course of which the eye had not appreciably varied.

The method of observation was very simple. The a upon which the disk revolved was connected by an endl band with a fly wheel of weight sufficient to insure the nec sary uniformity of motion. This fly wheel was turned by t observer, who increased its speed, watching the spectral regi under inspection, until the appearance of the above mention shadow indicated the transition from interrupted to continuo vision. The motion was then kept as nearly uniform as pc sible for one minute, during which an assistant counted tl revolutions of the disk. The observer, by watching the fiel of view mean time, could detect slight changes in velocity.

The following tables give some of the results obtained b this method. The wave-lengths are those of the middle o each spectral region. Although the brightness of the spectrun and the sensitiveness of the observer's eye were not the same ir the different series, they did not vary appreciably, so far as known, between the beginning and end of any single series.

Series A.

Spectral region.	Revolutions per minute.	Interval between exposures of retina.	Duration of exposure.
7420 (red)	136	0·1074 seconds.	0·00293 seconds.
6463 (orange)	150	0·0961 “	0·00266 “
6025 (yellow)	171	0·0850 “	0·00232 “
5415 (green)	140	0·1044 “	0·00285 “
4784 (blue)	130	0·1125 “	0·00306 “
4382 (violet)	88	0·1662 “	0·00452 “

Series B.

[Spectrum brighter than in Series A.]

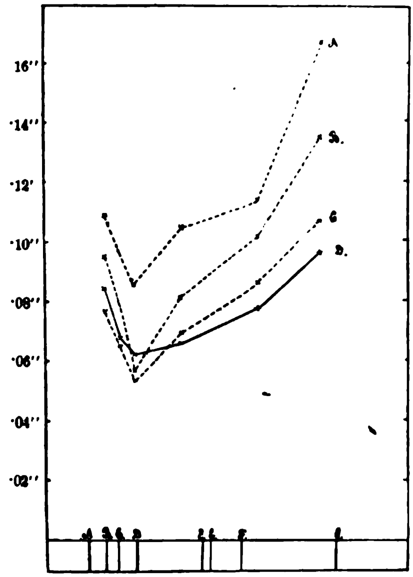
Spectral region.	Revolutions per minute.	Interval between exposures of retina.	Duration of exposure.
7420 (red)	154	0·0949 seconds.	0·00259 seconds.
6463 (orange)	186	0·0786 “	0·00214 “
6025 (yellow)	260	0·0562 “	0·00153 “
5415 (green)	180	0·0812 “	0.00221 “
4784 (blue)	144	0·1015 “	0·00277 “
4382 (violet)	108	0·1355 “	0·00369 “

Series C.

[Spectrum brighter than in Series B.]

Spectral region.	Revolutions per minute.	Interval between exposures of retina.	Duration of exposure.
7420 (red)	190	0·0769 seconds.	0·00209 seconds.
6463 (orange)	228	0·0641 "	0·00175 "
6025 (yellow)	280	0·0523 "	0·00144 "
5415 (green)	212	0·0690 "	0·00188 "
4784 (blue)	170	0·0860 "	0·00234 "
4382 (violet)	136	0·1072 "	0·00286 "

Inspection of these three tables and of the accompanying curves shows that the image formed by yellow light is less persistent than that produced by any other color, and that the duration of the image increases rapidly as we approach either end of the spectrum. Aside from the inaccuracies, inevitable in the comparison of single observations of this nature, the three curves representing series A, B, and C, are of the same general character. The minimum of duration is in the same region in each curve. It will be seen that the duration of the image is least in the series corresponding to the brightest spectrum and greatest with the darkest spectrum; and that changes in brightness affect the persistence of the images formed by the different spectral regions in nearly the same proportion.



The law of the dependence of the duration of color-impressions upon the intensity of the ray could doubtless be determined by repeating these measurements with spectra of known and varied brightness. The writer indeed made a series of preliminary measurements with this end in view. The spectrum of a gas flame was substituted for that of daylight and its brightness varied by the method of Vierordt, i. e. by changing the width of the slit. At the low intensities thus obtained the fluctuations in the sensitiveness of the eye were so great as to defeat the object in view. The observations only served to confirm the fact already established, that with diminishing brightness of the spectrum the image increases in duration.

By comparing the curves A, B, and C with that indicating the relative luminosity of different parts of the solar spectrum, as measured by Fraunhofer and independently by Vierordt, we find that the maximum of luminosity corresponds in position with the minimum of duration of the retinal image. The variations in luminosity of the different parts of the spectrum* are far greater than the changes in the duration of the color-impressions produced by the corresponding wave-lengths, but the two are not directly comparable because the luminosity was determined for a vastly brighter spectrum. The effective brightness of the spectrum for which the persistence of the retinal image was measured, was, according to Talbot's law for the luminosity of rotating black and white disks, only $\frac{1}{13}$ as great as that of the spectrum of uninterrupted daylight, seen through the same instrument. The difference is about that between the intensity of light reflected by white paper, on the one hand, and from a lamp-blacked surface on the other. Since the relative sensitiveness of the eye for different wave-lengths varies with the intensity of the ray, being proportionately much greater for the more refrangible rays when the intensity is small, the luminosity curve of a faint spectrum

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* The relative luminosity of different portions of the spectrum as determined by Fraunhofer and Vierordt are given in the following table. Their results are of interest in this connection because of the relation between the luminosity and the duration of the corresponding impression upon the retina. and because they show that the luminosity differs for different eyes in much the same way as the duration of the image is found to do.

Luminosity of the Spectrum.

Fraunhofer.[1]		Vierordt.[2]	
Red (B)	32	Red (B)	22
Orange (C)	94	Orange (C)	128
Yellow (D)	640	Yellow (D)	780
Yellow (D to E)	1000	Yellow (D to E)	1000
Green (E)	480	Green (E)	370
Blue-green (F)	170	Blue-green (F)	128
Blue (G)	31	Blue (G)	8
Violet (H)	5·6	Violet (H)	0·7

[1] Denkschrift der Bayerischen Akademie. 1815.

[2] Anwendung der Spectral-Analyse. Tübingen, 1871.

would be much flattened, at any rate toward the violet, and its values would be more nearly in inverse proportion to the duration of the retinal images, in series A, B, and C.

To determine whether the general form of the curve for the duration of color-impressions was the same for all eyes, Mr. Wilson Sterne, of Texas, who had been assisting the writer in the measurements already described, made the following set of readings. The conditions were the same as those under which series B had been obtained. As may be seen from the following table and from the corresponding curve (D), the variations n the duration of the image upon Mr. Sterne's retina are very different from those represented in series A, B, and C. The impression of yellow lasts longer, while the green and blue images fade more rapidly. These measurements were repeated many times, the curve always taking the general form shown in curve D.

Series D.

Conditions, those of Series B; Wilson Sterne observing.

Spectral region.	Revolutions per minute.	Interval between exposures of retina.	Duration of exposure.
7420 (red)	176	0·0831 seconds.	0·00226 seconds.
6463 (orange)	214	0·0683 “	0·00186 “
6025 (yellow)	238	0·0614 “	0·00167 “
5415 (green)	224	0·0653 “	0·00178 “
4784 (blue)	190	0·0770 “	0·00210 “
4382 (violet)	148	0·0988 “	0·00270 “

It seems very probable that no two observers would obtain the same curve, but our present knowledge of physiological optics is not sufficient to enable us to point out the true cause of the variation. Perhaps unusual sensitiveness of the eye to certain portions of the spectrum may lessen the duration of the corresponding color-impressions, just as the increased brightness of the ray itself is known to do. If this be true, the phenomenon stands closely related to color-blindness; the precise nature of the relation can only be determined by comparing the sensitiveness of individual eyes to different spectral tints with the duration of the image produced by the same colors.

A minor phenomenon observed during the course of these experiments seems to show that the duration of color-impressions does not depend, fundamentally, upon the wave-length of the ray producing them; but that it depends, like color itself, wholly upon the character of the nerves affected. When the entire spectrum of the intermittent ray was observed, with the disk in very slow rotation, so slow as to cause flickering even in the violet, the image of the yellow and green portions disappeared first, leaving behind it a dark violet band extending the whole length of the spectrum. By regulating the speed of the disk, this band could be maintained in a nearly quiescent state while the dominant color of each wave-length appeared and disappeared with the passage of each open sector. This phenomenon can be readily explained in the terms of the Young-Helmholtz theory of color, of the truth of which it affords at the same time new evidence. Each wave-length produces three separate impressions upon the retina, the sensation of red upon nerves intended for the transmission of that sensation, the sensation of green, and that of violet, upon nerves adapted to carry those impressions to the brain. These three impressions are blended in a resultant color-sensation, the nature of which depends upon the relative intensities of the components. Upon the wave-length of the impinging rays it depends only in so far as these have a greater or less power of affecting one or the other of the three sets of nerves. The effect of stimulating a "red," "green" or "violet" nerve, is always the sensation we call red, green, or violet, as the case may be, no matter what the nature of the stimulating agent, and *the varying duration of color-impressions is due primarily to variations in the rapidity with which these nerves recover from the action of the impinging ray.* Of the three primary sensations, green is the most transient and violet the most persistent. Upon this supposition it is easy to see that whatever may be the predominant tint of a ray of light under ordinary circumstances, the final impression, after the ray has ceased to act, will be one of violet.

This observation upon the spectrum of an intermittent ray is closely allied to a variety of well known experiments, in which color-impressions are produced by the slow movement of white objects upon a black ground. Aside from the dying away of one component of the image after another we have to take into account the varying rapidity with which different color-images reach their maximum intensity. To this latter cause von Helmholtz* and others ascribe the production of "subjective" colors in these cases. Taken in conjunction, the two causes are capable of producing a great variety of "subjective" tints. Those produced by the more rapid disappearance of the yellow and green portions of the image are similar to the colors which white assumes to green-blind persons, the depth of color depending upon the rate of rotation of the disk. As the disappearance of these components is followed by that of the red portions of the image, the effect will be that of partial red-blindness combined with green-blindness. Under varying velocity a white surface would successively become pink, rose-colored, purple and violet.

The duration of color-impressions varies also with the length of time the retina has been exposed. Plateau, in the paper already cited, gives a curious law for the velocities necessary to produce apparent uniformity of surface upon black and white disks. He found that any two disks composed of alternate black and white sectors will attain a uniform tint at the same velocity, provided the black sectors in the one are equal in width to each other and to the white sectors in the other disk. That is to say, a black disk with narrow white sectors presents a homogeneous surface at the same velocity as does a white disk with the same number of similiar narrow black sectors; and this holds true, no matter what the number and width of the sectors may be. In a more recent paper, Plateau gives some measurements of the rate of rotation of such disks. The law was not put to a test in his experiments, as it might have been, since the disks for which measurements were made were black, with white sectors never exceeding the black ones in width.

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* Von Helmholtz: Handbuch der physiologischen Optik, p. 380.

The present writer, to determine the manner in which the duration of the retinal image varies with the length of exposure, made use of black disks with two diametrically opposed, open sectors, the latter varying in width from 45° to 176¾°. Through the open sectors of these revolving disks the intermittent spectrum of a gas flame was observed, and, as in the experiments already described, the velocity of rotation was increased until the yellow portion of the spectrum ceased to flicker. From the velocity of the disk and width of the black and of the open sectors, was calculated the duration of the image formed during various exposures. The following table shows the results:

Exposure of retina,	Duration of the image,
0·0124 seconds.	0·0954 seconds.
0·0274 "	0·0824 "
0.0717 "	0·0717 "
0·1314 "	0·0654 "
0·2316 "	0·0463 "
0·4506 "	0·0409 "
0·7566 "	0·0327 "

These values are not in accordance with Plateau's law. The series, unfortunately incomplete, indicates that upon increasing the time during which the retina is exposed, the duration of the image approaches a finite minimum, (probably about 0·02″ for the intensity in question). By decreasing the exposure, however, the duration of the image would seem to become indefinitely extended. Plateau's law carried to the limit requires the duration of the image to become indefinitely long for an infinitesimal exposure, and to become zero for an exposure equal to a single revolution of the disk. We know by the study of after-images that their duration after short exposures of the retina may be very long, but that a long exposure should be followed by no after-images seems contrary to common experience.

The results of the experiments described in this paper may be briefly summed up as follows.

1. The study of the duration of color-impressions produced by different portions of the spectrum, confirms, in the main, the results reached by Plateau.
2. The persistence of the retinal image is a function of the wave-length producing it, being greatest at the ends of the spectrum and least in the yellow.
3. It decreases as the intensity of the ray producing the image increases.
4. The relative duration of the impressions produced by the different spectral colors, is not the same for all eyes.
5. The duration of the retinal image is in inverse order to the luminosity of the colors producing it.
6. Each wave-length of the visible spectrum produces three primary impressions, red, green and violet; of which green disappears most rapidly and violet is the most persistent. Upon the different rates at which these impressions die away depend to a great extent the "subjective" tints of moving objects.
7. The duration of the retinal image depends upon the length of time during which the eye has been exposed, being very long after short exposures and approaching a definite finite minimum value as the exposure increases.

University of Kansas, June, 1884.

ART. XXXII.—*Fulgurite from Mount Thielson, Oregon;* by J. S. DILLER.

THE occurrence of lightning-tubes (Blitzröhren) or fulgurites, as they are frequently named, in this country has received little attention and it is very rarely that specimens have found their way into our museums. This cannot be due to their scarcity for there is good reason to believe they are common in the western part of the United States. They deserve special attention because they are the product of an exceptional method of fusion.

The terms fulgurite and lightning-tube are frequently used synonymously; but it seems desirable that the former be applied to the substance resulting from the electric fusion and the latter to the tubular form in which fulgurite usually occurs.

Mr. L. C. Johnson has just called my attention to some lightning-tubes found by Mr. Silas Stearns on Santa Rosa Island south of Pensacola, Fla. Mr. Stearns reports that where the tubular fragments were found there was a crooked trail of them leading from a tree struck by lightning, so that in this case, as well as in the one noted many years ago (1790) by Priestly, their electric origin is clearly indicated. Each of the two fragments is about 50 centimeters long, and the diameter of the tube varies from 7 to 15 millimeters. The smaller one retains its cylindrical character, but the other while in a plastic condition was collapsed by the pressure of the surrounding sand. Notwithstanding the fact that the walls of the tubes are only about $0 \cdot 25^{mm}$ in thickness they are not fragile. They are pierced by numerous small openings, with fused edges, which help to make the surface very rough and irregular. Upon the outside the tubes are dull, but within they have a brilliant lustrous glazing. The fulgurite is translucent, of a light gray, almost white color, and contains many gas cavities. Under the microscope it appears for the most part perfectly clear and amorphous. There is rarely seen a light brown clouding, due to the presence of oxide of iron in the sand from which the fulgurite was produced by the electric fusion. Remnants of quartz grains may be discovered in the colorless glass, but they are not abundant.

Last summer a party of the U. S. Geological Survey, in my charge under the direction of Capt. Dutton, while making a reconnoissance of the Cascade Range, ascended Mt. Thielson, which is the most acute and precipitous peak south of the Columbia. It is the majestic remnant of a large deep crater to the southeastward. Ensign E. E. Hayden, who alone ascended the upper portion of the peak, reports that the last two hundred feet are very dangerous, the summit being small and the footing insecure.* Among the specimens collected upon the summit are several of fulgurite, that had been formed by the fusion of an interesting basalt, in which instead of augite, there is a rhombic pyroxene associated with the olivine. Chemical analysis has shown that the rhombic pyroxene is hypersthene. This basalt holds the same relation to hypersthene-andesite as ordinary basalt does to augite-andesite, and it may be designated *hypersthene-basalt.*

Although fulgurite is frequently formed by the fusion of loose sand it is seldom seen in connection with solid rocks. Saussure found the hornblende schist on the summit of Mont Blanc coated with drops and bubbles of blackish glass which were attributed to lightning. A yellowish enamel formed by the fusion of mica schist was observed by Ramond on one of the prominent summits of the Pyrenees. In the same region he found a similar effect produced upon fragments of siliceous fetid limestone. In all of these cases the fulgurite occurs as a purely superficial coating, and not in the form of lightning-tubes. It has also been observed in connection with phonolite (?) (Klingstein porphyr) in the Auvergne; and Humboldt found it on one of the very acute volcanic mountains of Mexico, where it had resulted from the fusion of "reddish trachytic porphry" (andesite?). The summit, like that of Mt. Thielson, is very small and precipitous, and the vesicular, spongy rock furnishes insecure footing. Here lightning-tubes were found penetrating the porous mass, and in several cases it seemed as if the fulgurite, welling up out of the tube, had overflowed the adjoining surface. The most interesting and extensive development of fulgurite, however, has been pointed out by Abich as occurring upon Little Ararat, in Armenia, where the whole summit of augite-andesite is perforated by numerous lightning-tubes to considerable depths. Wichmann examined the fulgurite microscopically and found it a pale green glass full of gas pores.

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* Since this article was written the author has ascended Mt. Shasta, Cal., and found upon its summit fulgurite in the form of incrustations and lightning-tubes.

The fulgurite of Mt. Thielson occurs in the form of a superficial coating and lightning-tubes. Although spread over a considerable surface, it is not evenly distributed, but is arranged in patches of drops and bubbles of glass in very much the same way as paint which has been put upon a greasy surface. The drops and bubbles of glass are translucent and have a greenish brown color. Many of them have conical depressions which appear to have been produced by atmospheric pressure while the fulgurite was in a viscous state. The thickness of the coating between the bubbles is about 0·2^{mm}, and lighter colored. At several places where lightning-tubes descend from the surface into the rock the fulgurite has accumulated around the hole. The rock is porous and at places even spongy. The cavities are lined with minute clear colorless crystals and it appears evident that this structure has not been produced by the electricity. Lightning-tubes, ranging in diameter from 10·5 to 20^{mm}, penetrate the rock a few inches. They appear to have been formed by lining preëxisting tubes and cavities with fulgurite; for there is no evidence of compression in the adjoining rock. The fulgurite walls of one of these tubes has a thickness of 2^{mm}; it is filled with round bubbles so as to be almost pumiceous and its interior is brightly glazed. The hardness of the fulgurite is a little below that of ordinary glass. It is rather tough, strongly lustrous, and has a specific gravity of about 2·[illegible] In the flame of an alcohol lamp thin splinters readily fuse without intumescence. The groundmass of the rock fuses much less readily than the fulgurite to a very dark glass. Small fragments of the fulgurite when heated become strongly magnetic. It appears to be entirely insoluble in strong acids, even in aqua-regia, and is not affected by boiling solutions of potassium hydrate or sodium carbonate. The accompanying figure (fig. 1) represents a section of one side of a lightning-tube and shows the relation of the fulgurite to the unaltered basaltic rock which appears beneath. Its line of contact with the fulgurite is irregular. The black-bordered olivine grains and crystals of feldspar project into it and show no prominent effects of the fusion, while the hypersthene is distinctly rounded on the edges and the groundmass has been melted much more readily than any other portion of the rock. The fulgurite is divided into two more or less distinct bands. The band (*c*) nearest the middle of the lightning-tube is a uniformly light coffee-brown glass, which contains a number of nearly spherical vesicles. Between the zone of pure fulgurite (*c*) and the unaltered rock (*a*) there is a narrower belt (*b*) in which the fusion has been less complete and the dark fluidal banding parallel to the length of the tube is prominent. This zone is frequently more or less granular. It is not only penetrated by crystals of feldspar, hypersthene and olivine projecting from the adjacent rock, but envelops numerous crystal remnants of these minerals scattered throughout. It contains some small round bubbles, but they do not appear nearly so abundant as in the fulgurite described by Wichmann from Little Ararat; nor have I been able to discover any radial arrangement in the longer axes of the larger vesicles. The superficial coating of fulgurite is composed wholly of coffee-brown glass without any marked fluidal structure.

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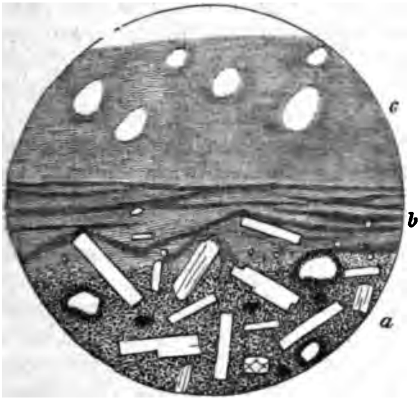
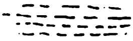


Section of one side of a Lightning-tube from Mt. Thielson, Oregon. *a.* unaltered hypersthene basalt; *b.* mixed zone; *c,* fulgurite.



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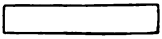

5.

A striking feature of the fulgurite is the absence of all products of crystallization from the electric fusion. It is true that fulgurite frequently envelops crystals and crystal fragments, but these are easily recognized as remnants of that portion of the rock melted to produce the fulgurite. They are not the products of crystallization from the electric fusion but from previous volcanic fusion. The entire absence of all crystallites and all microlites which are usually abundant in tachylyte, hyalomelane and obsidian may be used as a means of distinguishing fulgurite from other natural glasses. It is doubtless due to the fact that the source of the heat being very limited in both time and space, the cooling is so sudden that there is no opportunity given for the crystallizing forces to act before the mass is rigid. That the cooling takes place very suddenly is shown by the lightning tubes in loose sand where, by the electric current, the sand is thrust aside, a hole made, the sand fused, and the tube formed and cooled in many cases before the sand can rush together again to fill up the hole. In some cases, however, the pressure of the sand is so great that the tube while soft is collapsed without breaking. That the fulgurite was cooled very suddenly is shown also by the fact that when heated red hot for but two minutes in a Bunsen flame and then examined under the microscope the beginnings of crystallites can be readily detected. As already stated, the microscope revealed the fact that the fulgurite was formed chiefly by the fusion of the groundmass.

In order to determine more fully the character of the material melted, an attempt was made to crystallize the fulgurite. A completely amorphous fragment nearly as large as a pea was kept at a red heat in a Bunsen flame for six hours. It fused very slightly on the exterior and lost its vitreous character entirely. A thin section of it under the microscope showed that it had assumed a distinctly, radial-fibrous, microfelsitic structure. A larger portion of fulgurite was taken, finely pulverized and fused in a small platinum crucible before a blast lamp for nearly five hours without intermission. When cooled the fused mass in the lower part of the crucible was found to be clear and colorless, while the upper portion was tough, black and basaltic in appearance. Under the microscope the dark colored portion was found to be crowded with distinctly striated feldspar microlites and a multitude of others, very minute, which were indeterminable, besides many minute octahedrons of magnetite. Between these microlites, arranged in a basaltic fashion, could be detected a trace of pyroxene, apparently monoclinic, with considerable brownish glass and dark globulitic base. An interesting feature in this section is the accumulation of the smallest microlites into elongated groups (fig. 2) in which all the individuals are parallel, as if to indicate their ultimate combination to form a single crystal. The clear and colorless portion of the fused mass found upon the bottom of the crucible con-ned many perfect crystals of feldspar and shows very com- tely their development from bundles of microlitic fibers. ie fibrous bundles (fig. 3) frequently have irregular ends, but sides are generally straight. Consolidation begins in the ddle, as represented in figure 4, and gradually advances both ys, until a perfectly clear compact crystal of feldspar (fig. 5), thout any trace of fibrous structure, is completed. The elon- ted groups of parallel microlites (fig. 2) appear to be one of earliest stages in the development of the feldspar crystals this case, and growth is analogous to that of the hornblende stals described by Zirkel in the diorite from New Pass, Neva- . That the fulgurite is formed chiefly by the fusion of the undmass of the rock is shown clearly also by the following emical analysis made by Professor Clarke and Dr. Chatard in laboratory of the U. S. Geological Survey. The amount of gurite obtainable from the hand specimens was very small d sufficient for only a partial analysis. The alumina and n were estimated together, and the amounts of potash and da were not determined.

	Fulgurite.	Groundmass.
Silica (SiO_2)	55·04	55·85
Alumina (Al_2O_3) } Ferric oxide (Fe_2O_3) }	28·99	22·95
		4·59
Lime (CaO)	7·86	8·41
Magnesia (MgO)	5·85	3·08
Potash (K_2O)		2·67
Soda (Na_2O)		2·16
Loss by ignition	1·11	0·52
	98·85	100·23

The groundmass was separated from the olivine, hypersthene, d all but a trace of the feldspar by means of Thoulet's ution, and the magnetite was removed from it by hydrochloric d. The presence of a larger proportion of magnesia in the gurite indicates the fusion of some of the hypersthene.

Nearly all of the fulgurite is either superficial or confined the lining of preëxisting cavities. This is what we should pect from the well known fact that electricity always spreads elf upon the surface of a body. A small portion of the ful- rite, however, seems to have been produced within the adjoin- compact rock by fusing the groundmass. It occurs in small egular nodules or strings, frequently full of bubbles and occa- nally possessing a distinct fluidal structure approximately rallel to the course of the electric current. It is difficult to nceive how a distinct fluidal structure may have been pro- iced in these small masses, which were but momentarily scous and completely hemmed in upon all sides, unless it is ie to the repulsion of the particles among themselves. It is well known that particles electrified by a passing current repel each other most forcibly in the direction of the current, and this repulsion may perhaps explain the lines of motion in the enveloped fulgurite as well as those which are so prominent parallel to the length of the lightning tubes. To the same repulsion may be due, at least in part, the accumulation of fulgurite about the openings of small tubes upon the surface of the rock. In describing such accumulation one author has remarked that the tubes seem to have boiled over. The effusion of fulgurite from the tubes was doubtless facilitated by the expansion and forcible ejection of the air within the cavity. The heat developed in the rock by the lightning is only momentary and proportional to the electrical resistance. The high temperature of any individual crystal within the heterogeneous path of the current may depend chiefly upon the resistance which that mineral offers; for the elevated temperature is of so short duration that the increase due to conduction at any point would be small. The brevity of the whole operation indicates that the fulgurite is the product of fusion purely and not in any considerable degree due to the action of one part as a solvent upon another. On this account it is interesting to note that the order of fusion in the formation of fulgurite holds no definite relation whatever to the order of crystallization when the rock solidifies from a molten magma. The groundmass (last product of crystallization) with its numerous grains of magnetite (first product of crystallization) have yielded most readily to the heat developed by the passing current. Next to these the hypersthene shows the greatest amount of alteration, while the difficultly fusible feldspar exhibits but slight traces of modification and the infusible olivine remains wholly unchanged. So far as observations have yet been made upon the production of fulgurite by the fusion of a heterogeneous rock it appears that the amount of melting experienced by each ingredient depends chiefly upon its degree of fusibility.

Notwithstanding the valuable researches of numerous observers on the electrical characters of minerals too little is yet known to determine how important a factor the electrical resistance of each mineral may be in determining the composition of the fulgurite. On account of the diaphaneity of the conductor and the great strength of the current by which fulgurite is produced it affords an excellent opportunity for the study of electric fusion. The presence of a porous rock, rich in iron, upon a prominent, acutely pointed mountain-summit in a region of violent electric storms presents the most favorable condition for the extensive formation of fulgurite.

U. S. Geol. Survey, Washington, D. C., May 27, 1884.

XXIII.—*On the Paramorphosis of Pyroxene to Hornblende in Rocks;* by GEO. H. WILLIAMS.

ıas long been recognized that pyroxene and hornblende ɔ different crystallographic forms of essentially the same ıle, of which the former is most stable at high, the latter nary temperatures. As early as 1824 Mitscherlich and er melted tremolite at the potteries of Sévres and found n slowly cooling the mass crystallized in the form of [1] In 1831, G. Rose repeated the same operation with ite from the Zillerthal with the same result.[2] The con- of this change at temperatures of fusion has also been ıntly verified by the more recent experiments of Profes- ɔuqué and Michel-Lévy of Paris, who found it impossible ficially produce hornblende. In every case where this ıl was employed, it changed at high temperatures to .[3] In natural lavas hornblende crystals are frequently ed to have undergone alteration around their outer edge n aggregate of minute augite and magnetite crystals.[4] ȝ probably due to a caustic action of the magma, which, ount of an increase of temperature, partially dissolves the etely crystallized hornblende individual. The same ɜ is observed when any amphibole crystal is subjected for to the action of a fused basic rock.[5] Rose maintained ornblende in lavas was always younger than the augite, ȝ been formed at a lower temperature. Though further has failed to altogether substantiate this statement, the cant fact remains that, while all attempts to produce lende artificially have thus far been unsuccessful, augite lily obtained by simple fusion.

less conclusive is the proof that at ordinary temperatures gite molecules have a tendency to rearrange themselves hornblendic form. Here nature furnishes the evidence the laboratory fails to supply. In 1831 G. Rose de- ì crystals of hornblende, collected by him during his ıy with A. von Humboldt to the Ural Mountains, which sed the external form of augite.[6] Some of these were ound to have a core of true augite. At first they were ed as instances of parallel growths of the two minerals. ıbsequently Rose[7] himself gave the real explanation of ɪrigin by showing that the hornblende, which was fibrous

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g. Ann., xxii, p. 338, 1831. [2] Ib.

ıhèse des minéraux et des roches, Paris, 1882, p. 78.

)ebbeke: Neues Jahrbuch für Min., etc. I Beil. Bd., p. 474.

lter and Hussak: Neues Jahrbuch für Min., etc., 1884, i, p. 24.

g. Ann., xxii, 1831. [7] Ib., xxxii, p. 617, 1834.

in structure, had evidently resulted from a gradual and often incomplete molecular change of crystals originally altogether augite, just as monoclinic crystals of sulphur may be observed to slowly pass out into an aggregate of orthorhombic individuals when subjected to circumstances different from those under which they were formed. Later, Rose[8] and others described this alteration of pyroxene, to which he applied the name uralite, from many other localities, and with the introduction of the microscope as an aid in studying rocks it was found to be exceedingly wide spread.

It is generally conceded that temperature is not the only influence which conditions the crystalline form assumed by the pyroxene-hornblende molecules. Hornblende is often observed as a primary constituent of certain (generally acid) lavas, and it seems probable that augite *may* be formed at comparatively low temperatures. The chemical constitution of the mass in which the crystals are formed, as well as other conditions not now understood, are doubtless influential. Nevertheless, the general tendency on the part of the pyroxene-hornblende molecules to attain a state of stable equilibrium seems to be in the manner described above, since no change of augite into hornblende at high temperatures, nor of hornblende to augite at ordinary temperatures, has ever been observed.

Quite recently the possible wide-spread geological importance of the paramorphosis of pyroxene to amphibole in accounting for the existence of many areas of hornblendic rocks by the alteration of other rocks, originally augite, has attracted much attention. This change has been carefully followed in Norway,[9] Austria,[10] Saxony[11] and several other European localities,[12] as well as on this continent in New Hampshire,[13] Wisconsin,[14] and in the region about Baltimore.[15] In a large majority of cases the change seems to be to true uralite. Hypersthene and diallage as well as common augite and even compact original hornblende undergo an alteration, extending from the outer edge of the crystal toward the center, into aggregates of hornblende fibers whose axes are sometimes approximately parallel to those of the original crystal, sometimes not. In the Baltimore gabbros a zone of white hornblende, resembling tremolite, is generally present between the pyroxene and the green ralite, while the latter exhibits a marked tendency to become ompact along its outer edge.

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[8] Pogg. Ann., xxvii, p. 97, 1833.

[9] H. Reusch: Die fossilien-führenden Schiefer von Bergen, Norwegen, transl. by Baldauf, 1883.

[10] F. Becke: Tschermak Min. und Petr. Mitth., 1882, p. 157.

[11] J. Lehmann: Die altkrystallinen Schiefergesteine. Bonn, 1884, p. 190.

[12] Cf. A. Geikie in "Nature," June 5th, 1884.

[13] G. W. Hawes: Metadoleryte from Littleton, N. H. This Journal, III, xii, p. 136.

[14] R. D. Irving: this Journal, July, 1883.

[15] G. H. Williams: Johns Hopkins University Circulars, No. 30, April, 1884.

Instances of the change by paramorphosis of a pyroxene rystal directly into a single individual of compact hornblende, ithout the intervention of anything resembling uralite, have eretofore hardly been observed in sufficient perfection to place heir nature beyond all doubt. Augite crystals more or less completely surrounded with a rim of compact hornblende have frequently been described, but almost universally regarded as parallel growths of two original minerals, just as Rose at first explained the occurrence of uralite.[16] That this may indeed be the true explanation in some cases is most probable, but I am convinced that in many instances it is insufficient. In 1878 Dr. G. W. Hawes[17] figured and described an occurrence side by side of augite and basaltic hornblende as an instance of paramorphism and the same interpretation was put two years later by Professor R. D. Irving[18] upon similar cases occurring in certain Wisconsin rocks. In neither of these instances, however, are the proofs of paramorphism adduced entirely convincing. Several cases therefore, recently noted by the present writer, where such a direct change of pyroxene to compact hornblende is admirably exhibited in every stage, seem worthy of a brief description.

As members of that remarkable group of massive rocks exposed just south of Peekskill, on the Hudson River, to which Professor J. D. Dana has recently applied the name *Cortlandt Series*,[19] there are several apparently distinct types, occurring in the most intimate possible relations on the northern shore of Montrose Point. A microscopic examination, however, reveals the fact that these types are not in reality as distinct as they at first appear. They all consist largely of compact brown hornblende, together with more or less augite and hypersthene and a varying, though generally small proportion, of a basic feldspar. Their principal differences consist in coarseness of their grain and the relative amounts of the different bisilicates present. They were evidently all derived from one magma and exhibit very beautifully the structure termed by Fritsch and Reiss[20] "Eutaxitic," which is so commonly observed in acid lavas like trachyte and phonolite. All of these rocks which contain pyroxene show the direct change of this mineral to compact brown hornblende in an endless variety of cases. I shall only attempt to describe one or two where this process is especially apparent. These must serve as types of all rest.

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[16] Pogg. Ann., xxii, 1831.

[17] Mineralogy and Lithology of New Hampshire, pp. 57, 206, Pl. VII, fig. 1.

[18] Geology of Wisconsin, iii, p. 170, 1880. Cf. Vanhise, this Journal, III, xxvi, p. 29, July, 1883.

[19] This Journal, III, xx, p. 194, Sept., 1880.

[20] Geologische Beschreibung der Insel Teneriffe, 1868, p. 414.

One rock from the locality just mentioned consists o exceedingly fine-grained, jet black mass in which occasi bronze-colored crystals of hypersthene are easily visible to unaided eye. The microscope shows the groundmass to composed essentially of small oval grains of brown hornbl with here and there a similarly shaped crystal of hyperstl or plagioclase. The large porphyritic crystals of hyperstl are all undergoing paramorphosis to single individuals of br hornblende. Fig. 1 represents one of these magnified th diameters. The interior portion is readily recognized u the microscope as hypersthene in which the characteristic clusions are quite intact wherever the original substanc unaltered. The hypersthene core is surrounded by a zon perfectly compact brown hornblende whose external bound

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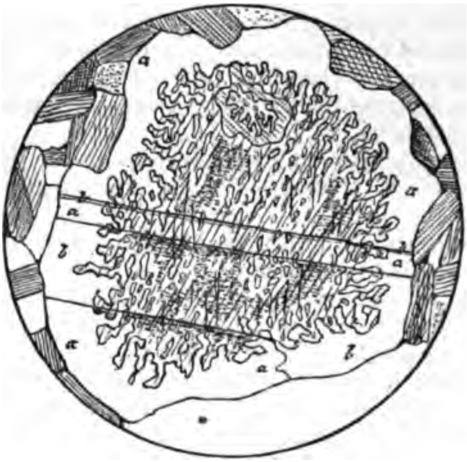

while showing no signs of crystal planes, is only so far irre lar as the development of the crystals of the groundmass ly adjacent to it requires. The interior boundary of this however, i. e. the line of contact between it and the hy sthene core, is the most irregular imaginable. The most d cate possible tongues and shreds of hornblende extend fr the outer rim into the hypersthene in every direction, thou they seem to be most developed in the direction of its cleav Moreover the entire surface of the hypersthene as displaye the section, except in a few spots, where, as already obser the characteristic inclusions remain, is covered with the s tongues and shreds of hornblende of a delicacy and ten hich it is impossible either to adequately describe or portray. he hypersthene and hornblende substance, which are well stinguished by differences of color and optical orientation, e not in reality separated by sharp lines of contact, as from e nature of the case it is necessary to represent them in a awing in black and white. They everywhere shade into one other by insensible gradations. The transition is so gradual at it is often impossible to detect the exact point where it curs even with the highest power of the microscope. Every- ing in the slide seems to indicate that a slow change from one ineral to the other is in progress, which has started at very any points throughout the entire body of the crystal and is ly complete around its outer edge. A short examination of is section would, I think, be sufficient to convince any one at this is no instance of a parallel growth.

The optical orientation of this secondary hornblende is very emarkable, and shows conclusively that the alteration is to a ingle, perfectly homogeneous crystal, corresponding in all espects to the original hypersthene individual. Nowhere does he secondary mineral exhibit any signs of a fibrous structure. Even the smallest and thinnest particles are perfectly compact nd all are identical in their optical behavior. The hyperthene crystal, as can be readily seen between crossed nicols, s a polysynthetic twin, consisting of several lamellæ. The osition of the twinning trace, though not visible in ordinary ight, has been indicated on the drawing. Curiously enough ll the hornblende connected with the hypersthene has precisely he same optical arrangement. The larger middle portion, as vell as the fine lamella (marked *b* in the figure) of both the ypersthene and hornblende are in twinning position to the wo ends and the smaller middle portion (marked *a*), and all the articles of hornblende, whether around the edge or upon the urface of those hypersthene lamellæ having the same crystalographic position, extinguish the light between crossed nicols t the same instant, while all particles contiguous to the other ypersthene lamellæ are seen to be in twinning position with elation to them. The twinning trace divides the finest shred f hornblende as sharply as it does the hypersthene substance, nd the narrow lamella, *b*, extends across the hornblende rim ust as though it were part of the original crystal.

If additional proof were needed it would seem to be furnshed by the smaller crystal of hypersthene inclosed in the pper part of the larger one. This exhibits in a smaller scale ll the phenomena just described. It is also surrounded by a one of compact hornblende, which evidently extends to the imits once occupied by the hypersthene. There are the same regular patches of hornblende over the surface, but here, the original crystal being simple, the secondary mineral all has the same optical orientation.

Fig. 2 exhibits a similar case of paramorphosis of augite to brown hornblende in another section of the same rock. The crystals are cut nearly perpendicular to their vertical axes and show very plainly that their orthopinacoids are parallel. The change has here taken place in somewhat larger patches than in the former instance and the boundaries between the two minerals are somewhat more distinct, but there can be little doubt that the process is the same in both.

These two cases described in some detail must be regarded as typical of a great variety of others, nearly or quite as good, which when taken together make the evidence of paramorphosis, at least as far as the particular rock in question is concerned, very satisfactory. It has been already mentioned that the groundmass of this rock is composed almost entirely of rounded grains of compact brown hornblende. Interspersed among these are frequent hypersthene grains of precisely the same shape and in every possible stage of transition to hornblende, which is apparently identical with that making up the bulk of the groundmass. The supposition, therefore, that this was originally a hypersthene rock (norite), like others which occur in close connection with it, and that its present form (diorite) has been due to gradual molecular alteration, seems quite natural, although not perhaps capable of rigid proof.

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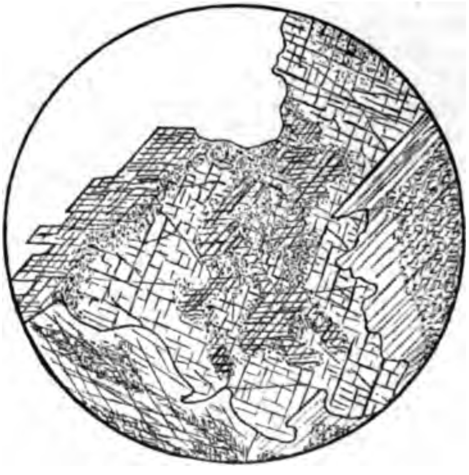

Several rocks from other localities have come to my notice which seem also to show strong indications of the direct change of pyroxene into compact hornblende.

[icroscopic sections of gabbros from Eagle Harbor, Ash· l Co., Wisconsin, the possession of which I owe to the kind- ı of Professor R. D. Irving, show the undoubted change of pyroxene into single individuals of compact brown horn- ıde, as recently described by him,[21] although in none that I e examined is the change as plainly exhibited as in the rocks n Montrose Point. The wernerite-hornblende rock, in con- tion with which the apatite deposits of Scandinavia occur, e been recently studied by H. Sjögren,[22] who called them *rediorites.* They are regarded by this author as a peculiar es of a gabbro, formed from this by the paramorphosis of feld- : to wernerite and of pyroxene to hornblende. Both brown green hornblende are produced in this way. I am indebted Ir. Frank D. Adams, of the Canadian Geological Survey, for opportunity to study a series of sections of both the Swe- ı rocks and others exactly like them, occurring in connec- . with the apatite deposits near the Ottawa River in Canada. of these show the gradual change of pyroxene to compact ɜn hornblende in a manner closely resembling that exhibited the Cortlandt rocks.

'he so-called "black granite" from Addison, Me., seems to e originally been an augite-plagioclase rock containing ıe biotite. The augite, however, is to a large extent under- ıg paramorphosis to corresponding crystals of compact ɜn hornblende, and so far has this process progressed, that rock would now be classed as an augite diorite or at least a proterobase. In the Baltimore gabbros the change of lage to compact green hornblende has been observed, ough far less frequently than that to uralite. Doubtless ıy cases which have been described by European litholo- s as parallel growths of pyroxene and hornblende might be better explained by paramorphosis.

Before leaving this subject it may not be uninteresting to ıire into a possible *cause* of the change, by molecular 'rangement, of pyroxene to amphibole. It is well known ; dimorphous substances require different conditions for the ımption of their different crystalline forms. The molecular ıpings, of which such forms are the outward expression, not accidental but must always be in accordance with the umstances under which they were produced. If the condi- ıs most favorable for the assumption of one form are sequently changed to such as are more favorable for the ıtence of the other, then the molecules are no longer in a

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Geology of Wisconsin, vol. iii, 1880. Third An. Report of the Director of J. S. Geol. Survey, p. 105. Copper-bearing Rocks of Lake Superior. Mono- hs V.

Geol. Fören. i Stockholm Förh., 1883, vi, 447. Cf. Neues Jahrbuch für Min., 1884, I, ref. 81.

state of perfectly stable equilibrium. Were they free to move, they must at once rearrange themselves to suit the altered conditions, but if they have passed into the solid state, this tendency to rearrangement may not be sufficient to overcome the force of cohesion. Sometimes indeed, as in the case of monoclinic sulphur or arkansite, the crystal structure is actually pulled to pieces and the matter rearranged in accordance with existent circumstances. More frequently, however, the molecular tendency can only manifest itself in an optical disturbance. Mallard[23] has recently shown that crystals of boracite above 265° C. become altogether isotropic, and Klein[24] has argued from this fact that the mineral is dimorphous, crystallizing in the regular system above, and in the orthorhombic system below this temperature. Merian[25] has also shown that tridymite becomes optically hexagonal at high temperatures, and, according to Klein,[26] even leucite loses its twinning lamellæ and behaves like a regular mineral at a temperature considerably below its fusing point. The effort of the molecules to change their arrangement in accordance with the change of temperature here produces a tension, resulting in optical derangement but no new form.

In the case of the dimorphous pyroxene molecule there must be a similar tendency to assume the hornblende form, which, as we have seen, is the most stable one at ordinary temperatures. It is not probable, however, that this tendency alone would be sufficient to effect a complete change of crystalline structure. If, on the other hand, the assistance of some external agency could be introduced, which would render the molecules more or less mobile without increasing their temperature to a point where the augitic mode of arrangement is more stable than the hornblendic, it will readily be seen that they must assume the form best in accordance with the lower temperature. Just such an external agency as this would seem to me to be furnished by the *pressure* to which rocks are subjected in the formation of mountains. If hornblende is melted, the molecules become easily movable and a rearrangement naturally takes place to suit the altered conditions. The reverse of this process it would be very difficult to accomplish in the laboratory, but in nature it appears to be the commoner of the two. The recent experiments of Spring as well as the observations of Heim and others in the Alps, seem to indicate that pressure may cause molecular movements in solids without rupture, just as heat does. Of course this pressure produces heat but acting as slowly as it does in the elevation of mountains, there is no reason to assume that the actual temperature of the rocks is thereby raised to anywhere near the point of fusion. May not then the force which has elevated the mountain chains have been also an efficient cause of the paramorphosis of pyroxene in rocks? Certainly this idea gains great support from the exceedingly intimate association of schistose hornblende rocks with perfectly massive gabbros and diabases in many different localities. In the great gabbro area west of Baltimore the massive diallage and hypersthene rocks occur everywhere imbedded in and passing by gradual transitions into more or less schistose amphibolites, which differ from them mineralogically only in the crystalline form of the bisilicate constituent. These amphibolites have throughout the whole area a nearly parallel strike and dip, and many other facts, which cannot here be enumerated, indicate that their schistose structure is, like slaty cleavage, the result of lateral pressure. That the amphibolites have resulted from the paramorphosis of the pyroxene in the gabbros is abundantly proven both by microscopic study and their relations in the field, and the fact is very significant that throughout the area, as a rule *the schistose structure is developed in proportion to the completeness of the paramorphosis.*[27] This could hardly be explained except by the supposition that both were produced by the same cause. Unless a mass of rock were absolutely homogeneous, a lateral pressure exerted upon it would not act equally at every point. Wherever its action was greatest, there it would first tend to develop a schistose structure, perpendicular to the direction of pressure, and there too it would probably first render the paramorphosis of pyroxene to amphibole possible.

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[23] Bul. Soc. Min. de France, v. p. 144, 1882.

[24] Neues Jahrbuch für Min., etc., 1884. i, p. 185 ref., ib., p. 237.

[25] Ib., 1884, i.

[26] Nachrichten der kön. Ges. d. Wiss. Göttingen, May, 1884.

According to the recent very admirable descriptions by Dr. J. Lehmann[28] of the so-called "Flasergabbro" group near Rosswein and Penig in Saxony, the phenomena there exhibited are apparently very similar to those displayed by the gabbros near Baltimore. The action of lateral pressure was so great as in many cases to have caused an actual crushing of the massive diallage-hypersthene rock and the result has been a schistose amphibolite enclosing lenticular masses of unaltered gabbro.

The association of schistose hornblendic rocks with massive ones containing pyroxene is known at very many localities both in Europe and this country. Jukes long ago suggested that many areas of hornblende rocks might be accounted for by the alteration of old lavas, and this idea seems now to be fast gaining ground. It seems probable that we here have a wide-spread and very interesting phase of metamorphism, the alteration of one rock to another resulting from the change of crystalline structure in a dimorphous constituent, due to pressure and change of temperature from a higher to a lower.

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[27] The writer hopes soon, under the auspices of the U. S. Geological Survey, to be able to fully illustrate the very interesting relations existing between the Baltimore amphibolites and gabbros.

[28] Ueber die Entstehung der Altkrystallinen Schiefergesteine, etc., Bonn, 1884, p. 190, et seq.

It is not my desire to claim that pressure is the only cause of the paramorphism of pyroxene, or, indeed, that it is ever absolutely necessary. The range of observations is as yet too small to allow of any generalization. These thoughts are thrown out as suggestions and it will in future be interesting to note whether this change has taken place on as large a scale, if at all, in the rocks of undisturbed regions, as in those which show unmistakable signs of having been subjected to great pressure.

Johns Hopkins University, Baltimore, May 30, 1884.

ART. XXXIV.—*On the Southward ending of a great Synclinal in the Taconic Range*; by JAMES D. DANA. With a map (Plate III.)

[Read before the British Association at its session in Montreal.]

THE Taconic question, although American in its facts, bears no less profoundly on foreign than on American geology; for it is largely a question as to the age and origin of crystalline rocks. I have therefore thought the subject an appropriate one for a meeting of the British Association.

My stratigraphical work in the region of the Taconic Range, begun in 1870, I have continued during the last two years; and it is my purpose to present some of the results of my recent investigations.

The discussion with regard to the Taconic rocks has been greatly complicated, from the first, by Professor Emmons's extension of the term Taconic to the rocks of other regions besides those of the original Taconic, because they were *supposed* to be—not proved to be—*supposed* to be of the same age and system. My work has been among the *original* Taconic rocks, those of the Taconic Range and its bordering limestone, which, together, gave to geology, through Professor Emmons, the term Taconic and the first facts and conclusions on the subject; and of these alone I speak.

This Taconic Range extends along the western border of New England, between Middlebury in central Vermont on the north and Salisbury in northwestern Connecticut on the south, and encroaches by its western slopes a little on the State of New York. The distance between these points is about 150 miles. The line of ridges, after dwindling to a low narrow strip in Salisbury, continues on southward; and this continuation is geologically a part of the range, although it does not bear the name on maps; but of this more southern portion I do not now propose to treat.

The general conclusions presented by me in earlier papers, published in this Journal from 1872 to 1881, are fully sustained by my more recent studies, and I therefore briefly state them.

First: as to the rocks. The schistose rocks constituting the Taconic Range vary gradually, as we go from north to south, from argillyte or roofing slate and the smooth, faintly crystalline hydromica (or sericite) schist, to chloritic mica schist, and still coarser kinds of mica schist containing garnets and staurolites.

Secondly: as to the structure of the range. These schistose rocks constituting the range lie, in general, in synclinals or compound synclinals. In the narrower portions the beds dip eastward across from west to east, leaving it ambiguous whether the uplift is anticlinal, or synclinal, or monoclinal. But in other wider portions the beds of the two sides dip toward the axis of the range, and often at a small angle, thus exhibiting the fact that in such parts the structure is synclinal, and rendering it probable that it is so elsewhere.

Thirdly: as to the unity, or not, of the eastern and western limestone belts. These belts of crystalline limestone, one extending along the east side of the Taconic Range, and the other, less continuously, along the western, blend with one another through broad low regions or valleys crossing the Taconic line, and thus prove that they are portions of one formation.

Fourthly: as to the stratigraphical relations of the limestone and schist. The great limestone formation passes underneath the schist of the Taconic Range as a lower member in the mountain synclinals; and, consequently, the eastern and western limestone belts are outcrops of opposite sides of such synclinals. To give the proof on this point for a part of the range is one of the objects of this paper.

Fifthly: as to the age of the limestone and schist. The limestone, which is part of the Taconic system, and, as just stated, an underlying member, contains, at various points in central Vermont and eastern New York, shells, corals and crinoids of the Lower Silurian, ranging in age from the inferior divisions of the Lower Silurian to the superior. Hence, the schists of the Taconic synclinals, which overlie the limestone and are younger than it, are of *later* Silurian age, and probably of the age of the so-called Hudson River group or Upper Llandeilo flags

The subdivision of the Taconic system into an *older* and a *newer* Taconic was first made by Professor Emmons, the propounder of the system. But the division was not based on any facts connected with the *original* Taconic rocks—those of the Taconic Range—but on the perplexing facts that beset the subject after additions of other Taconic rocks and regions had been made. No facts favoring in the least such a subdivision have been reported from the Taconic Range.

Among those broader portions of the Taconic Range in which the pitch of the beds is for the most part toward the axis of the mountain and in this fact bear positive evidence of a synclinal structure, there is the elevated region called Mount Washington, situated in southwestern Massachusetts and northwestern Connecticut. This Mt. Washington portion of the range is that referred to in the title of my paper—"*On the Southward ending of a great Synclinal in the Taconic Range;*" and to the description of it I now proceed.

Mount Washington rises boldly above the limestone plains and valleys adjoining it. Its length is about twelve miles, and its average width five miles. The limestone area on the east of it, in Sheffield, Massachusetts, and the bordering part of Connecticut, is nearly ten miles wide, and that on the west, in Copake, about three miles wide. The summit of Mount Washington (called Mt. Everett) has a height of 2,624 feet above the sea. The mean height of the extensive summit region is over 2,000 feet, and 1,300 feet above the limestone plains at its eastern, western and southern base.

The accompanying map shows, on a scale of 0·8 inch to the mile, the outline of the southern part of the mountain area of the schist (the part in Connecticut), and the limestone at its base: the portion shaded (by transverse lining) being that of the limestone.* The circles enclosing Fe indicate the localities of iron-ore pits. For the heights on the map I am indebted to Mr. Pettee, civil engineer and surveyor, of Lakeville, Conn.

There are also isolated ridges of schist in the limestone portion (the oblong white areas on the map); and there are a few small areas of limestone (lined on the map, like the rest of the limestone) within the region of the schist, one near Copake on the west side, and nine others in the southwestern part.

I will first state the facts which prove the structure of the mountain to be synclinal.

First. The dip, both of the schist and limestone, along the opposite sides of Mt. Washington in Massachusetts, is toward the axis of the mountain. On the west, the dip is eastward—usually between 30 and 60 degrees. On the east side, it is westward; in a large portion, only 10 to 25 degrees or not diverging widely from the horizontal, but in other parts ranging up to 45 degrees, and also to 60 and 70 degrees. (On the map the strike and dip are indicated by T-shaped symbols; the length of the stem of the T is inversely as the amount of dip, and the point of junction of the top and stem marks the locality of the observation.) In an east-and-west section through the highest point of the mountain (the peak, Mt. Everett, in Massachusetts,) the dip on the west side in Copake is 40 to 50 degrees eastward; at Mt. Everett, which is near the eastern border, 35 to 60 degrees westward; and at the base directly below, in Sheffield, 15 to 30 degrees westward. At the latter place [which is near the house of L. Roys] the limestone makes the lower 150 feet of the eastern front, and above it are the beds of schist, their cut edges making its face.

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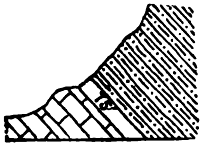
* The map accompanying this article, presented to the British Association, included the whole of Mount Washington. I propose to publish soon a map of all of Berkshire, and another of Salisbury and Canaan, with full details.

1.



2.

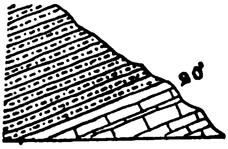


Figure 1 is a section of the beds at the western foot, and fig. 2 a section at the eastern.

My observations on the dip at other points in Massachusetts sustain the conclusion as to the synclinal character of the mountain-mass.* The synclinal is really a compound synclinal, that is, contains within it subordinate anticlinals and synclinals. This is suggested by the two limestone valleys running deeply into the mountain area on the north, and by the occurrence, within the area, near its southern border, of small limestone belts, as already pointed out.

2. The general synclinal character of the mountain is indicated also about its southern extremity. In the southernmost of the small limestone areas in this part of the mountain, numbered 1 on the map, the limestone in one part was bare for a breadth only of a few yards, the mica schist overlying and concealing it on either side and to the south. Here a quarry was opened for the sake of the limestone, and consequently the cover of

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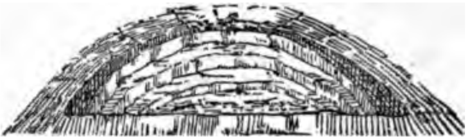
* The following are some observed strikes and dips at the eastern base:
In Massachusetts, near the northern end, schist N. 35° W., 10°–15° W., and limestone, 40′ off, N. 55° W., 20°–25° W.; about 2 m. south, schist 15°–20° W., limestone N. 10° W., 15°–20° W.; 2 m. farther south, schist, about 25° W.; ½ m. N. of the line of the State, schist N. 20° E., 50°–55° W., limestone, 75′ off same. In Connecticut, just south of line, at Sage's ravine, schist N. 20° E., 50°–65° W., limestone ½ m. east, N. 22° E., 60°–70° W., but varying much. The dip of the schist increases southward, and a mile south is 90°, and two miles south has some easting; the limestone just east of it generally dips westward. (See map.)

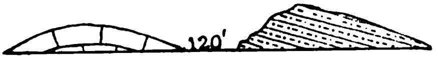
schist was removed, so as to reveal the anticlinal position of the rocks. The schist now caps the limestone on all but the upper side, as shown in fig. 3, a view of the quarry. The dip of the limestone is southeastward in the eastern part, but southward in the southern, the latter being the direction of the axis of the little anticlinal.

3.

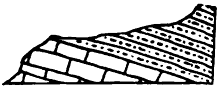


In the limestone area No. 2, which is but a few rods from No. 1, there is another similar anticlinal of limestone; but the schist is not here seen in actual contact with the limestone, owing to the soil between (fig. 4); and hence, although the dip indicates that the schist is the overlying rock, the case is not as satisfactory as the preceding. In another small area, No. 3, the limestone and schist are in contact, and dip together northward at the low angle of 20 degrees, as in fig. 5.

4.



5.



The other areas of the group are longer belts and have the dip of the limestone throughout eastward, and mostly 30 to 50 degrees: and since the limestone is the underlying rock, as number one indicates, they are all, if not monoclinal, as is hardly possible, small overturned anticlinals, which have had their tops worn off so as to show the limestone beneath. The very narrow strip, No. 9, the westernmost of the number, outcrops in the bottom of a small trench occupied by a brook, and the outcrop has a width of but three to four yards. The stream has here worn through the schist to the subjacent crystalline limestone. The handsome mottled coloring of the limestone has led to the designation of the place as a marble quarry, although no quarrying has yet been carried on.

3. The synclinal structure of the mountain is apparent also along portions of the southern edge of the schist. At Ore Hill, one and a half miles west of Lakeville (ore-pit *b* on the map) the schist overlies limestone; for the bed of limonite with which limestone occurs is reached by excavating through 40 to 60 feet of more or less decomposed schist—as may be seen on the southeast side of the ore-pit; while at the Chatfield

-pit (ore-pit *c*) 400 yards south, the schist fails, and only ft material covers the limestone and ore.

The ore-pits that have been opened about the base of Mt. ashington, fourteen in number, are situated near the junction the limestone and schist; and, in view of the facts that have :n mentioned, this means—*near where the limestone emerges m beneath the schist.* I here add that the iron ore (*limonite*, as the miners call it, *brown hematite*) has resulted from the dation of iron, the iron existing in some state of combina- in the limestone and schist, and chiefly, I believe, in the estone.

The facts presented appear to be sufficient proof that the icture of the Mt. Washington part of the Taconic range is iclinal.

The dying out of the Mount Washington synclinal southward some features of special interest.

In the first place, the schist area abruptly narrows (as is seen the map) along an oblique line through the village of Lakele, from a breadth of four miles to that of six-tenths of a e near Ore Hill.

In the second place, while the mountain three miles north of keville is 1,200 feet high above the limestone, it is only 150 t high in the narrow neck to which it is reduced near Ore ll.

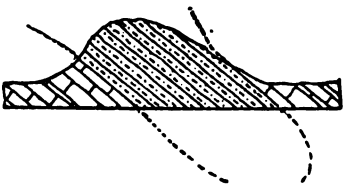
Again, the pitch in the beds in the last three miles is thward in some parts, instead of eastward or westward, wing a flattening out of portions of the synclinal and subinate anticlinals. But these southward pitching surfaces rnate with others that have the usual northward strike. e variations in strike and dip are so frequent that the direcns could not be indicated on a geological map unless it were de on a very large scale. The small areas of limestone in southwestern portion, numbered 1 to 9, are, as already plained, the sites of some of the local anticlinals—of those of m which had the underlying limestone so near the surface t erosion has succeeded in exposing it to view.

It thus appears that in the dying out of the synclinal, besides attening of portions of the general synclinal and the introction of southward dips, there was also a multiplication of all subordinate flexures.

Further, there is a multiplication of ridges of schist in the iestone area.

Several such ridges, some quite small, are situated, as the ip shows, southeastward of the mountain near the village of lisbury; and others occur farther east. They consist of the ne mica schist as the mountain, and look like fragments of the same formation. They are not, however, horizontally-bedded fragments; for they have, generally, an eastward dip, often a high dip; and the facts seem to show that most of them are *synclinal* flexures; that they occupy the troughs of local synclinals in the limestone; that, as Mt. Washington consists of schist contained in a broad limestone trough, these isolated schist ridges, except in the case of an occasional monoclinal or anticlinal, occupy narrow troughs. Most of them were, apparently, half-overturned troughs, so pushed over westward that the dip of the schist is generally eastward, as illustrated in fig. 6; and thus they are like those of the Taconic Range just north of Mount Washington. The ridges to the southwest of Mount Washington are of like character, though larger and less numerous.

6.



The statement that these isolated ridges are for the most part synclinals, I could illustrate by numerous sections from other parts of the Taconic region; but this would lead me from the special subject before us, and I leave it for another occasion.

I close by enumerating some of the subjects illustrated by the facts that have been presented, and a few of the conclusions flowing from them.

1. The facts have illustrated the features of a mountain synclinal; its compound synclinal structure; its variations in character as it dies out. As the mountain is a *synclinal* with subordinate anticlinals and synclinals in its mass, so what is now a broad limestone area was (as I might make clear, if not so already) an area of *anticlinals* with subordinate synclinals and anticlinals; and the schist ridges occurring isolated in the limestone stand in general in the synclinal troughs of the limestone area.

2. As the schist is the overlying rock of the region, and exhibits the cut edges of its beds in the precipitous sides of the mountain above the limestone, this schist once spread over the limestone area; and the stratum, judging from the greatest height of Mt. Washington, was at least 2,000 feet thick.

3. The limestone, which spreads to a width of three miles about Copake, west of Mt. Washington, continues southward and southwestward by two lines to the Hudson River. The wider and more northern belt reaches the river at Poughkeepsie, having one break of three miles in its course, and at some points it contains well-characterized Lower Silurian shells,

corals and crinoids. This fact, paralleled with that of the occurrence of similar mountain-synclinals and Lower Silurian fossils in the Taconic region of Vermont, affords paleontological evidence of the Lower Silurian age of the limestone of the Mt. Washington part of the Taconic region; and, since the fossils are partly those of the Trenton period (or Llandeilo group), they make, as has been stated, the schist of the mountain to be that of the Upper Llandeilo flags or Hudson River group.

4. Since the schist of the mountain is not older than the Llandeilo flags, or the upper beds of the Lower Silurian, it follows that not only roofing slate, hydromica schist, and chloritic hydromica schist, but also coarse mica schists, garnetiferous and staurolitic, have been crystallized at as late a period in geological history as the close of the Lower Silurian.

5. These crystalline rocks were crystallized and rendered garnetiferous and staurolitic while lying in beds over a great limestone formation of Lower Silurian age, which also was at the same time rendered crystalline.

6. The making of the extensive ore-deposits (beds of limonite, some of them over 100 feet deep), through oxidation and the decay of rocks, could not have commenced before the close of the Lower Silurian; and, after the close, it would not have been commenced before an emergence of the rocks from the ocean had taken place, since air is needed, as well as water, for such oxidation. In view of the occurrence of limestones of the later Upper Silurian (Lower Helderberg group) overlying the upturned Lower Silurian and Cambrian slates of eastern New York near Hudson in Becraft's mountain and Mount Bob, and looking as if portions of a once extensive Upper Silurian formation covering much of New York State east of the Hudson River, it is probable that the emergence of the rocks from the ocean just referred to did not take place before the end of the Upper Silurian.

The conclusions I have presented as regards the synclinal character of Mount Washington and the rest of the Taconic range, and the Lower Silurian age of the rocks, is the same that was held and put forth by that most thorough and cautious geologist, the former able head of the Geological Survey of Canada, Sir William Logan.* The chief point of difference between us is that he, under the then existing paleontological evidence, made the limestone to precede instead of to include the Trenton group. In stratigraphical conclusions we are one.

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* [Full credit to earlier and later authors who have published essentially the same view as to the stratigraphy, I have given in former papers, the latest in a per in the Journal of the Geological Society of London for 1882.]

ART. XXXV.—*On supposed Glaciation in Pennsylvania south of the Terminal Moraine;* by H. CARVILL LEWIS, Professor of Geology in Haverford College. With a map (Plate IV, but not numbered.)

IN a "Report on the Terminal Moraine in Pennsylvania and Western New York,'[1] I have said (p. 45) that "with the exception of a narrow district which I have called the *fringe*, the line of drift hills which crosses Pennsylvania lies at the precise edge of the drift-covered district," and (p. 43) that this terminal moraine is a "line separating the glaciated from the non-glaciated regions."

But in his letter of transmittal, Professor J. P. Lesley, the State Geologist, in referring to the limit of glaciation, makes the following statement:[2]

> "Two remarkable phenomena, however, stand in the way of a positive and final assertion respecting the limit of the southward extension of the northern ice, in spite of the well-marked line of its terminal moraine, viz: scratches observed on the mountains of Schuylkill and Dauphin County; and vast grooves or notches in the crest of the Kittatinny mountain, for which no explanation is suggested by the drainage system of the country.
>
> (1.) "Respecting the first very little can be said, but that little is important.
>
> "In 1850–51 Professor Edward Desor of Switzerland, and myself, observed glacial scratches pointing southward upon the bare outcrop of conglomerate which makes the crest of Locust mountain west of Ashland. The testimony of the distinguished glacialist to their genuineness is sufficient. We were both of us perfectly well acquainted with the nature and aspect of 'slickensides' and felt sure that these polished surfaces, grooves, etc., were not of that kind, nor could they have been produced in that way; for they crossed the eroded edges of the beds.
>
> (2.) "Some years afterward I observed horizontal grooves traversing the natural vertical east wall of the small and unique notch in the crest of the Fourth mountain where it is crossed by the turnpike from Harrisburg to Halifax. The opposite west wall had been cut to the vertical by the engineers, and was covered with sections of blast holes; but the east wall had not been touched, and was covered with *horizontal* glacial grooves and scratches crossing the deeply south-dipping bed-planes. In this case I had no one with me to verify the observation, but I feel as sure of the nature of the exhibition as in the former case. . . .
>
> (3.) "The Wind Gap is one of the strangest and most inexplicable features of the earth's surface. . . . I am not aware that any

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[1] Report Z. Second Geological Survey of Pennsylvania, Harrisburg, 1884.

[2] P. xli.

us attempt has been made to construct a satisfactory hypoth- of its origin. . . . A long, straight, sharp-crested ridge, 1000 high on a base two miles wide, is here, not split by a fault, gapped by a stream, but worn smoothly through to half its ude. The raggedness of the mountain crest ceases and othly rounded slopes descend to the smoothly rounded bottom e gap which is lined with sand and gravel. . . It is evidently ep cross-groove smoothly made and finished by some agent of ion acting slowly and continuously—but an agent quite differ- from a river. . . . I can see no serious objection to the sup- tion that the front of the ice-sheet may at one time have ad- ed the necessary two miles and banked itself against the ntain at the Wind Gap. . . . In any future investigation of origin of the Wind Gap the fact that there extends south- d from the level of the bottom of the Gap, a fan-shaped slop- plain of rounded bowlder drift which has evidently all come ugh the Wind Gap, and has probably been brought through y the agent which made the gap (although that cannot be n for granted) must be taken into consideration."

rofessor Lesley then repeats an explanation for the origin he Wind Gap which he made in 1882, that it was due to overflow of a vast lake which he supposed to cover a large t of Monroe and Carbon Counties, which lake was due to a at ice-dam at the Lehigh Water Gap. But as this dam ld have had to be 1100 feet high in order to deliver the er over the crest of the mountain when the Wind Gap was un, and as the glacier did not cover the region about the igh Gap, he grants that such a supposition is untenable.

4.) He then mentions a topographical feature six miles west he Lehigh Gap, saying:

It looks as if the bowl had been made by some kind of water- ; but if so the mass of water must have been extraordinarily at and must have shot clear of the top of the mountain—an ngement only possible in case the back valley were filled with to a height exceeding that of the mountain."

n addition to the passages just quoted, there are a number ther statements made by different geologists which describe ther supposed evidences of glaciation in Pennsylvania south he terminal moraine.

5.) Mr. C. E. Hall has published two short papers which are o quoted in the preface to Report Z. In the first of these[3] calls attention to the bending over of slate outcrops both rth and south of the Lehigh Gap, which he regards as due to e southeastward movement of a glacier.

(6.) Mr. Hall also mentions a mass of debris a few hundred rds north of the gap, concerning which he says:

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[3] Proc. Amer. Philos. Soc., xiv, 620.

> "The only explanation I can give of this, is, that it is a moraine formed by the glacier after it had receded through the gap, possibly a lateral moraine."

He also believes that the Wind Gap shows evidence of the passage of a glacier.

(7.) In his second paper[4] entitled "On Glacial Deposits in West Philadelphia," he describes a gravel opening between Spruce and Walnut streets west of 45th street in West Philadelphia, where, having found bowlders of Oneida conglomerate, Medina sandstone, Triassic shales, and probably Clinton and Oriskany, as also a few pieces of trap, he says:

> "From all these evidences I have concluded that this belt of drift deposit is no other than a glacial moraine formed by the Schuylkill glacier receding from the site of the city."

He states also:

> "that the surface of the gneiss where laid bare is comparatively smooth, and shows evidence of having been polished, though so soft as not to retain the marks of glaciation."

(8.) Prof. F. Prime, Jr., has stated[5] that

> "A glacial moraine may be traced from the Wind Gap in the Kittatinny Mountain through Ackermanville, Bangor and Williamsburg to Portland on the Delaware river. . . . West of the Wind Gap no glacial moraine can be seen so far as the Lehigh river. That it existed, however, there is little doubt, and was probably washed away again by aqueous action, to be re-deposited as modified drift," etc.

(9.) Again he says in the same communication:

> "Another glacial moraine also exists in the Saucon Valley south of the Lehigh; it extends from Friedensville almost to Bingen station on the North Pennsylvania railroad."

(10.) In his report on Lehigh County,[6] the same geologist states that, "distinct evidences were obtained of glacial deposits," and records his conviction that

> "the glaciers, coming through the gaps of Kittatinny Mountain and in places riding over its crest, came down to the South Mountain."

In the statement that in Lehigh County glacial scratchings "were, with a single exception, nowhere found; the subsequent erosion of the soft slates of the Hudson River group, and of the soluble underlying limestones, having removed all traces of any scratches which may have existed" he appears to add strong evidence of the truth of his conviction.

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[4] Proc. Amer. Philos. Soc., xiv, 633.

[5] Proc. Amer. Philos. Soc., xviii, 85.

[6] Report DD, pp. 75–77, 1878.

(11.) Prof. J. F. Carll in his valuable report on the Oil Regions[7] includes an extended discussion of the glacial drift, and holds that

> "besides the main southward movement of the glacier, every feature in the Allegheny valley south of Olean shows an ice movement *toward the north*," and "as there is no red rock in the northern branch valleys and no northern detritus in the southern branch valleys, . . . it follows that the northern ice-flow, southward, met a southern ice-flow, northward, and both moved westward side by side."[8] He makes the origin of this northward flowing glacier in the "upper branch valleys of the Allegheny River in Potter and M'Kean counties," and believes[9] that the Salamanca "Rock City" was formed by glacial erosion.

These eleven localities, each lying south of the terminal moraine, some of them considerably so, are, I believe, the only ones in Pennsylvania south of that line which have been regarded as showing evidences of glaciation by geologists of acknowledged ability. Several local writers in the State have mistaken weathered trap bowlders for glacial erratics, or fallen into similar obvious errors,[10] but these are not worthy of mention.

If these statements, given in such detail, remain unquestioned facts, it must be granted that the "terminal moraine," so-called, is a misnomer, and that the evidences usually relied on to distinguish glaciated from non-glaciated regions are insufficient.

It seems to be of importance therefore, that any investigations of the terminal moraine should be supplemented by careful inquiries into all reported evidences of glaciation south of that moraine.

It is proposed, therefore, to review each of the above eleven statements in turn.

The accompanying map represents by small colored circles the approximate position of each of the localities of supposed glaciation south of the moraine, numbered in accordance with the following descriptive paragraphs.

(1.) The striæ on the crest of Locust Mountain west of Ashland, and south of Mt. Carmel, have been frequently referred to,[11] and since they lie "25 miles south-southwest of the great moraine (Berwick)" are of the highest importance.

I have crossed Locust Mountain in three places west of Ashland, have walked along its summit south of Mt. Carmel for a considerable distance, and have explored, on foot and by driving, the valleys both north and south of the mountain for many miles in each direction. I have also carefully examined the sides and ledges of the mountain and, thanks to careful instructions and a diagram given me by Professor Lesley, believe that I have succeeded in finding the very spot where Professors Lesley and Desor saw the striæ.

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[7] Report III. [8] Loc. cit., p. 379. [9] p. 390.

[10] History of Chester County, Smith and Futhey, p. 186. History of Bucks County, Davis, p. 438, etc.

[11] MacFarlane's American Geological Railway Guide, p. 102. Report G6, xvii, Second Geological Survey of Penn., etc.

I found no moraines, no till, not a single transported or scratched bowlder, no kames or terraces, and no striæ. There was not a single sign of glaciation, and both mountains and valleys were in all respects similar to other non-glaciated mountain regions about the anthracite coal basins.

The mountain is formed mainly of Pottsville conglomerate (No. XII), a coarse white conglomerate with often large pebbles, and here characterized by numerous impressions of an unusually large calamite, probably *Calamites dubius* Artis (*Calamites bistriatus* Lesq.).

The impressions of this calamite are sometimes two to three feet long and from one to three inches in width, and are marked by a series of narrow parallel furrows, running longitudinally. The articulations are unusually distant and the parallel lines well marked. The impressions of this calamite are flat or only slightly rounded, often entirely colorless, no trace of the original fossil remaining, and, appearing often merely as a set of parallel lines crossing a face of conglomerate, have probably been mistaken for glacial striæ. The impressions of these calamites occur on the very ledge near the top of the mountain south of Mount Carmel which was supposed to be glaciated.

(2.) On the summit of Peters (Fourth) Mountain, where the Dauphin and Halifax turnpike crosses the sharp crest, is a small notch, some 15 feet deep, the east and west sides of which are nearly vertical walls of Pocono sandstone. The sandstone dips 65° S. 10° E., and there is a small coal vein in it part way down the mountain. After an examination of the region between here and Harrisburg, including the slopes and crest of the mountain, I was unable to find any trace of glacial action. The east wall of the notch is covered by numerous horizontal striæ, as stated by Professor Lesley, but these striæ are not of glacial origin, but are undoubtedly *slickensides.* The slickensides occur on the cleavage planes of the sandstone, these cleavage planes being at about right angles with the plane of bedding. Unlike a glaciated surface, the rock forms projecting angular crags, with irregular faces, cut by a series of cleavage planes, on several of which the slickensides appear. The slickensides do not make continuous lines nor occur on a single plane, thus differing from glacial striæ. Nor do they occur only on the surface, but run in *between* blocks of sandstone not yet separated. I hammered down some of these blocks and found the slickensides quite as well marked on the inner surface of the block just detached as they were on the vertical wall. This locality is over sixty miles south of the terminal moraine.

(3.) When studying the limits of glaciation in 1880 and 1881, I was aware of the statements that had been made concerning glacial action at the Wind Gap, and took special care to examine that locality thoroughly, particularly as it lies so near the terminal moraine. Within three miles of the gap, glaciation is proved by undoubted evidences. Scratched and transported bowlders, some of them of Adirondack granite, polished and striated rock surfaces, unmodified *till*, glacial lakes, kames and moraines, are all close at hand, but all stop suddenly at a point less than three miles away. I did not see a single scratched or transported bowlder in the gap, nor any striæ or other signs of glaciation. A long trench made for a projected railroad had been cut in the bottom of the gap, offering an excellent opportunity to study the character of the debris at that place. It presented no evidence of glacial action. The fragments were mostly angular, and composed of the same Medina sandstone (No. IV) which formed the two sides of the gap. They had evidently fallen there from the mountain. The "smoothly rounded slopes" referred to showed no evidence of glacial or aqueous erosion, their form being due to the mass of angular frost-broken talus which covers some of the crags.

North of the Gap, and at nearly the same level, the soil is filled with fragments of Clinton red shale and sandstone (No. V), being made of the underlying rock. No rounded or transported bowlders were here seen, although cliffs of Helderberg limestone and Oriskany sandstone occur immediately north. A few miles to the northeast, however, in the glaciated region, large blocks of both of these formations are strewn in abundance along the northern flank of the mountain.[13]

Nor could any "fan-shaped sloping plain of rounded bowlder drift" south of the gap be discovered. It is true that the whole valley south of the gap is strewn with water-worn rounded bowlders and with beds of clay, both of which were brought by waters issuing from the melting glacier a few miles eastward. I have been able to trace the course of a wide river, which, issuing from the base of the glacier west of Bangor, flowed westward past Pen-argil and Hellerville into the valley of Bushkill Creek, and thence to the Delaware. Another great stream flowed down the valley of Martin's creek, while at the same time there was a large sub-glacial drainage backward to Portland, as shown by the Portland kame.[14] The bowlders and

[13] V. Report Z, p. 88.

[14] Z, p. 69.

the bowlder-bearing clay which cover a great part of Northampton County south of the Wind Gap have clearly not come through the gap, but from the glacier on the south side of the mountain.

Immediately in front of the gap there is a great mass of sharp, frost-broken talus of Medina sandstone, which forms a sloping plain leading up to the gap. The rock fragments are not rounded or water-worn, but angular and often of large size. I am led to believe that all this work was accomplished long before the Glacial epoch.

An example on a small scale of the power of waters to carry sandstone blocks far away from their original outcrop, may be profitably studied within a few miles of Philadelphia, near King of Prussia, a locality which I briefly described some years ago.[14]

The Wind Gap does not seem to require any unusual or extraordinary origin. Like most mountain gaps, it appears to be the result of long continued pre-glacial erosion.

Its smooth outlines seem to me to be due to the uninterrupted course of atmospheric influences. Had a stream flowed through it in recent times, the talus would have been carried off and the sides of the gap become steep, as at the neighboring Delaware and Lehigh Gaps.

Still another consideration bears against the idea that the Wind Gap was cut down by a glacial stream.

A number of studies at points along the extreme edge of the glaciated area, where the moraine crosses river valleys, have led me to believe that neither the glacier at its cap nor the waters issuing from it have been able materially to modify the topography. In many cases the terminal moraine lies on the very floor at the bottom of a narrow valley. Had the glacial or post-glacial waters been able to excavate such a valley, the moraine would now lie *above* the stream. As instances, we have the moraine crossing the valleys of Fishing Creek, Columbia County; Great Valley Creek, Cattaraugus Co., N. Y.; the Susquehanna, Allegheny, Conewango, and Beaver Rivers. The evidence gathered from the conditions, on these and many other streams, is all opposed to any theory that the Wind Gap was made either by glacial waters or by ice.

(4.) The same arguments, that have been used in referring to the Wind Gap, are just as appropriate in considering the extraordinary hypothesis proposed to account for the Bake-oven. There is the strongest proof of the absence of all glacial action at this place. I find no evidence that the glacier approached the Bake-oven nearer than twenty miles.

(5.) The Lehigh River was one of the great waste-weirs of the melting glacier. All the way from Hickory Run, where the moraine crosses it, down to its junction with the Delaware, heavy masses of water-borne drift mark the ancient flood, and show that it was 200 feet in depth. Where the banks of the river are steep, as they generally are as far down as the Lehigh Gap, the drift is represented by scattered bowlders only, all the rest having been washed away. Just north of the gap, for example, at a point one mile below Weissport, I found a large rounded bowlder of conglomerate six feet long lying upon a bank of shales of VIII, at an elevation of 150 feet above the river. Smaller ones occur up to a height of 180 feet. But south of the gap, where the easily eroded slates of III form an open rolling country, large masses of bowlders imbedded in a yellow brick clay cover the region on both sides of the river in beds sometimes more than ten feet deep. This deposit differs from glacial till in the rounded character of its bowlders, in the greater preponderance of clay, and in its more or less evident stratification. It certainly cannot be said to have "all the characteristics of a glacial deposit." It overlies Hudson River slate which, as Mr. Hall observed, is broken and crushed over, though not by a superincumbent glacier. The decomposed slates were naturally bent and crushed as the bowlder-laden flood crushed over them. Other cases could be cited at localities fifty miles farther south. A similar occurrence above the Lehigh Gap, also described by Mr. Hall, is of like character and origin.

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[14] Proc. Acad. Nat. Sc., 1880.

(6.) The mass of debris across the mouth of the Aquanchicola Creek, supposed by Mr. Chance and Mr. Hall to be a moraine, has none of the characters of a moraine, either topographically or internally. Such accumulations are common at the meeting of two drift-laden streams. The materials are water-worn, and the bank is leveled off by water, presenting none of the contours of a true moraine. I could find no trace of glaciated surfaces anywhere in the vicinity. There is in fact nothing to indicate that this bank of drift is at all unusual or different from the other deposits along the Lehigh, which are the evident result of aqueous deposition.

On the so-called "Eddy-hill" just north of the Lehigh Gap I found no rounded stones or drift of any kind, and there is nothing to indicate that this conical hill made of Clinton red shale has been materially modified in shape since pre-glacial times.

(7.) In a former paper[11] I have endeavored to show that Mr. Hall was mistaken in supposing that there is a glacial moraine in West Philadelphia. The gravel deposit at that locality is identical with that which occurs all along the Delaware from Trenton to Wilmington, and belongs to what I have called the

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[11] The Surface Geology of Philadelphia and vicinity. Proc. Acad. Nat. Sc., 1880.

"Philadelphia brick clay" and the "red gravel." It is a stratified deposit made at a time when this region was submerged to a depth of about 180 feet, and is bordered by the "Upland Terrace." It is, I believe, also a mistake to state that the underlying gneiss shows signs of polishing. As elsewhere about Philadelphia the gneiss is decomposed, and some of the decomposed portion has been mingled with the lower strata of the gravel. At many localities in the vicinity the gravel may be seen lying on very uneven surfaces of gneiss quite unlike the floors beneath true till.

(8.) Professor Prime has very naturally confounded the true moraine at Bangor and Ackermannville with the *Kame* which runs through Williamsburg (Mt. Bethel) and Bangor.[15] The topographical features of kames and moraines are very similar, and without a special examination of their internal structure are liable to be confounded.

(9.) The supposed moraine in the Saucon valley is merely a deposit of stratified drift, similar to those already described on the Lehigh and at Philadelphia. The bowlders are water-worn, not scratched, and lie at an elevation less than 180 feet above the river at Bethlehem.

(10.) Professor Prime's remarks about glaciation in Lehigh and Northampton Counties, south of the terminal moraine, prove to be due to the difficulty of distinguishing at times, between glacial *till* and aqueous deposits. It is true that as the glaciated area is approached from the south, the stratified surface deposits become very like true glacial drift. The bowlders become more numerous and larger, and stratification is not so evident. Occasionally also striæ are seen on the bowlders, especially in the larger river valleys, where the water was deep enough to float icebergs. Both Professor I. C. White and myself have experienced some difficulty of this kind in the valley of the Susquehanna, southwest of Berwick. But the absence of typical till, of striæ, and of moraines, and the fact that the deposits south of the terminal moraine are limited to districts below a fixed elevation, serve to distinguish them. I do not here include that, as yet, unexplained phenomenon which, more clearly shown in the western part of the State, I have called "*the fringe.*"

As to the glacial striæ in Lehigh County, Professor Prime has admitted to me that his reference to them was due to a mistaken observation.

(11.) The only evidence upon which Professor Carll rests his conclusion as to the northward flow of a McKean County glacier, appears to be[16] the occurrence of pebbles and bowlders of the red rocks of the Mauch Chunk (XI), Pocono (X) and

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[15] v. Report Z, p. 52, 53, 62.

[16] Report III, p. 379.

Catskill (IX) formations in the valley of the Allegheny river at Olean and Allegany, the rocks mentioned occurring only to the south of these towns. But he seems to forget that the Allegheny river flows northward to these points, and that it is just as capable of carrying rock debris northward as the Delaware is of carrying it southward. There is no necessity for a glacier as a transporter.

I have made a careful examination of the high region which Professor Carll would make a glacial center, and have found in it no trace of glaciation. No smoothed rock surfaces, no striæ, no till, no perched erratics, and no striated pebbles were noticed in McKean County, which I believe to have completely escaped the glaciation that has invaded every other county of the northern tier in this State. The Salamanca "Rock City," which Mr. Carll thinks was cut down by a stream of ice, is a remnant of a nearly horizontal sheet of Pottsville conglomerate (XII). It lies just south of the moraine and probably within the "fringe." But that it is due either to the glacier or to the glacial floods is extremely improbable. "Rock cities" like "pulpit rocks" and "monument parks" are characteristic of a non-glaciated region, where long continued atmospheric erosion has been uninterrupted either by glaciers or floods. The well known function of a glacier is to obliterate angular prominences, not to create them. I have been able to find no glacial marks of any kind at the Salamanca Rock city, nor any evidence that its origin was different from that of the Olean Rock city or similar phenomena elsewhere in the non-glaciated district.

In conclusion, I may perhaps be permitted to say that, while regretting the necessity of making personal allusions to those for whom I have the highest regard, I have felt it to be necessary both in answer to certain requests that have been made,[17] and also as a vindication of my deduction as to the truly terminal character of the Pennsylvania moraine.

Germantown, Pa., July 28, 1884.

ART. XXXVI.—*On a mass of Meteoric Iron from Wichita County, Texas;* by J. W. MALLET.

THE following is the history of the Wichita County meteoric mass, as given me by Hon. Henry P. Brewster, Commissioner of Insurance, Statistics and History of the State of Texas, a gentleman whose personal knowledge of the State in its early days is extensive and accurate.

The meteorite was found on the upper waters of Red River, in what is now the county of Wichita, not far from the Red River itself, on the opposite side of that stream from the part of the Indian Territory at present set apart for the Kiowas, Comanches and Apaches. It had been set up as a kind of "fetich" or object of worship or veneration by the Indians, "who revered it as foreign to the earth and coming from the Great Spirit," at a point where several converging trails indicated periodical visits to the spot. In 1858 or '59 Maj. Neighbors, then commanding at Fort Belknap, sent a wagon after the mass, and had it brought into the fort. It was thence sent in a government wagon to San Antonio, and subsequently moved to Austin, and there deposited in the old Capitol building, where it remained until the destruction of the building by fire some three years ago. Removed from the ruins, it was placed in a passage on the ground floor of the temporary Capitol now in use while the new and very handsome structure, intended for the permanent seat of the State government, is being erected. During last winter the meteorite was turned over by the State authorities to the University of Texas, and is now preserved in the University building at Austin.

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[17] *Science*, vol. ii, No. 41, p. 654.

The mass has an irregular, elongated pear-like shape, somewhat flattened, a good deal larger at one end than the other, with tolerably smooth general surface, but with well marked concavities or shallow pittings—in every way presenting the appearance of a typical metallic meteorite. There is no well-defined crust, but merely a thin, closely adhering film of oxide on the surface. There is no appearance of any effect from the Capitol fire through which it passed; very probably the weight of the mass may have carried it rapidly, on the giving way of the floor, down to some position in the basement in which it was sheltered from the heat by masonry rubbish accumulated over it. The dimensions of the specimen in its original state were—

Maximum length	595	millimeters.
Maximum breadth	305	"
Maximum thickness	223	"

The weight was a little under 160 kilograms, as determined on a rather rough platform balance.

A piece was cut off one end in order to display the character of the interior. Most of the iron was compact, and tolerably soft, tough and malleable. Here and there occurred nodules of troilite of considerable size, the principal ones ranging from 5 or 6 up to 23 millimeters in diameter. Signs of the presence of thin plates of schreibersite could be seen even without the use of acid, but that ingredient is not very abundant. The average specific gravity of the whole mass was probably pretty fairly represented by that of a slice weighing 204 grams, which was found =7·841 at 24° C.

A polished surface having been etched with nitric acid, Widmannstättian figures were clearly brought out, the broad bands of crystalline nickel-iron (with finer subordinate markings upon them) contrasting strongly with the more sparingly occurring, well-defined, lustrous lines of schreibersite.

Chemical analysis of an average sample of the shavings taken off by a planing machine in cutting through the mass gave:

Iron	90·769
Nickel	8·342
Cobalt	·265
Manganese	*trace*
Copper	·018
Tin	·004
Phosphorus	·141 [*]
Sulphur	·016
Graphitic carbon	·190
Silica	·132[†]
Magnetic oxide iron	
	99·877

A separate examination of the troilite nodules proved them to consist of ferrous sulphide with a little nickel and traces of manganese and chromium. The nickel may very possibly have existed in the form of minute granules of nickel-iron or schreibersite, and the chromium may in like manner be referred to an admixture of little particles of daubréelite.

The most interesting point about this specimen is perhaps the probability of its forming a separate portion of the same meteoric fall from which was derived the large iron meteorite, weighing 1635 lbs., first described by Col. Gibbs in 1814, and which has long been a prominent object in the mineralogical collection of Yale College at New Haven, Connecticut. The latter is said to have been found "near the head of Trinity River, a few miles west of the Cross Timbers, Texas, lat. 32°7′, long. 95° 10′ west of London." It is said to have been "one of a large number of meteoric masses which are reported to exist at the locality mentioned above." The statement of locality is not quite clear; the spot designated by latitude and longitude is in the northern part of the present Cherokee County, near the line of Smith County, and rather on the head waters of the Neches than of the Trinity, though not far from the latter, and about 240 miles from the locality in Wichita County where the meteorite now described was found. Even such a distance

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[*] **Both of course variable with the distribution of schreibersite and troilite.**

[†] **Silica perhaps originally present as iron silicide—magnetic oxide iron doubtless from outside surface.**

perhaps does not altogether exclude the idea of simultaneous fall, and it is of course quite possible that the mass found to be regarded with attention and veneration by the Indians may have been by them carried to the spot where they afterwards preserved it. There seems to be some uncertainty as to how many meteoric irons from Texas have before now been noticed, and are to be found in the mineralogical collections of the world. In a catalogue of the collection of Professor C. U. Shepard, published in 1857, in the second part of his treatise on mineralogy, p. 436, there is mentioned a meteoric iron from "Texas (Red River), U. S. A., found in 1808." In Rammelsberg's *Handbuch der Mineralchemie* (Leipzig, 1860) are noticed, p. 917, specimens from "Red River in Louisiana," and from "Texas," with the statement that according to Partsch these are probably identical; this opinion is undoubtedly correct; the analyses quoted show that both represent the Yale College specimen. In the recent (1880) catalogue of meteorites in the collection of the Indian Museum at Calcutta, No. 108 is quoted on p. 38, as two specimens from "Red River, Texas, U. S. A., found in 1814," No. 27, on p. 31, as a specimen which "apparently has been fired, from Denton County, Texas, U. S. A., found in 1856," and No. 39, on p. 32, as from "Brazos River, Texas, U. S. A., found in 1856." It may be questioned whether Nos. 27 and 39 refer to portions of the same or of different masses; the same date is given, but the shortest distance from any part of Denton county to the Brazos is about 40 miles, this county being traversed by affluents of the Trinity. The specific gravity of the iron now described agrees closely with that reported for the Gibbs meteorite of the Yale College collection. The results of the chemical analysis are also very similar to those obtained for the latter by B. Silliman, Jr. and Hunt. It is stated that this latter "encloses a few small masses of magnetic pyrites;" this statement probably referring to troilite nodules like those which are conspicuous enclosures in the University of Texas specimen. The Widmannstättian figures developed by etching this University of Texas iron do not closely resemble those of the Yale College specimen, as shown in a lithographed figure published in connection with the (Göttingen) inaugural dissertation on metallic meteorites of Wm. S. Clark (1852), copied from one published by Professor B. Silliman, Jr., but the difference of appearance may be largely due to difference in the planes of section in relation to those of crystallization in the particular pieces submitted to the etching process.

University of Virginia, August 11, 1884.

ART. XXXVII—*Jean-Baptiste-André Dumas;* by J. P. COOKE.*

JEAN-BAPTISTE-ANDRÉ DUMAS was born at Alais, in the south of France, July 14, 1800. His father belonged to an ancient family, was a man of culture, and held the position of clerk to the municipality of Alais. The son was educated at the college of his native place, and appears to have been destined by his parents for the naval service. But the anarchy and bloodshed which attended the downfall of the First Empire produced such an aversion to a military life that his parents abandoned their plan, and apprenticed him to an apothecary of the town. He remained in this situation, however, but a short time; for, owing to the same sad causes, he had formed an earnest desire to leave his home, and, his parents yielding to his wish, he traveled on foot to Geneva in 1816, where he had relatives who gave him a friendly welcome, and where he found employment in the pharmacy of Le Royer.

At that time Geneva was the center of much scientific activity, and young Dumas, while discharging his duties in the pharmacy, had the opportunity of attending lectures on botany by M. de Candolle, on physics by M. Pictet, and on chemistry by M. Gaspard de la Rive; and from these lectures he acquired an earnest zeal for scientific investigation. The laboratory of the pharmacy gave him the necessary opportunities for experimenting, and an observation which he made of the definite proportions of water contained in various commercial salts, although yielding no new results, gained for him the attention and friendship of De la Rive. Soon after we find the young philosopher attempting to deduce the volumes of the atoms in solid and liquid bodies by carefully determining their specific gravities, and thus anticipating a method which thirty years later was more fully developed by Hermann Kopp.

About this time, young Dumas had the good fortune to render an important service to one of the most distinguished physicians of Geneva, whose name is associated with the beneficial uses of iodine in cases of goitre. It had occurred to Dr. Coindet that burnt sponge, then generally used as a remedy for that disease, might owe its efficacy to the presence of a small amount of iodine; and on referring the question to Dumas, the young chemist not only proved the presence of iodine in the sponge, but also indicated the best method of administering what proved to be almost a specific remedy. It was in connection with this investigation that Dumas's name first appears in public. The discovery produced a great sensation, and for many years the manufacture of iodine preparations brought both wealth and reputation to the pharmacy of Le Royer.

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* From the Proceedings of the American Academy of Science vol. xix, Boston, 1884.

Soon after, Dumas formed an intimacy with Dr. J. L. Prévost, then recently returned from pursuing his studies in Edinburg and Dublin, and was induced to undertake a series of physiological investigations, which for a time withdrew him from his strictly chemical studies. Several valuable papers on physiological subjects were published by Prévost and Dumas, which attracted the notice of Alexander von Humboldt, who on visiting Geneva, in 1822, sought out Dumas and awakened in him a desire to seek a wider field of activity than his present position opened to him. In consequence he removed to Paris in 1823, where the reputation he had so deservedly earned at Geneva won for him a cordial reception at what was then the chief center of scientific study in Europe. La Place, Berthollet, Vauquelin, Gay-Lussac, Thenard, Alexandre Brongniart, Cuvier, Geoffroy St. Hilaire, Arago, Ampère, and Poisson, all manifested their interest in the young investigator. Dumas was soon appointed Répétiteur de Chimie at the École Polytechnique, and also Lecturer at the Athenæum, an institution founded and maintained by public subscription for the purpose of exciting popular interest in literature and science; and from this beginning his advancement to the highest position which a man of science can occupy in France was extremely rapid.

In 1826 he married Mdlle. Herminie Brongniart, the eldest daughter of Alexandre Brongniart, the illustrious geologist, an alliance which not only brought him great happiness, and at the time greatly advanced his social position, but also in after years made his house one of the chief resorts of the scientific society of Paris. The many who have shared its generous hospitality will appreciate how greatly, for more than half a century, Madame Dumas has aided the work and extended the influence of her noble husband.

1828–29 Dumas united with Théodore Olivier and Eugène Péclet in founding the École Centrale des Arts et Manufactures, an institution which met with great success; in which, as Professor of Chemistry, Dumas rendered most efficient service for many years, and in 1878 had the very good fortune to aid in celebrating the fiftieth anniversary of his own foundation, and to see it acknowledged as among the most important and efficient scientific institutions of the world. In 1832 Dumas succeeded Gay-Lussac as Professor at the Sorbonne; in 1835 he succeeded Thenard at the École Polytechnique; and in 1839 he succeeded Deyeux at the École de Médecine. Thus before the age of forty he had filled successively, and for some time simultaneously, all the important professorships of chemistry in Paris except one. This exception was that of the College of France, with which he was never permanently connected, although it was there that he delivered his famous course on the History of Chemical Philosophy, when temporarily supplying the place of Thenard.

Dumas early recognized the importance of laboratory instruction in chemistry, for which there were no facilities at Paris when he first came to what was then the center of the world's science; and in 1832 founded a laboratory for research at his own expense. This laboratory, first established at the Polytechnic School, was removed to the Rue Cuvier in 1839, where it remained until broken up by the revolution of 1848. The laboratory was small, and Dumas would receive only a few advanced students, and these on terms wholly gratuitous. Among these students were Piria, Stas, Melsens, Leblanc, Lalande, and Lewy, with whose aid he carried on many of his important investigations. By the Revolution of 1848 Dumas's activities were for a time diverted into political channels; but under the Second Empire his laboratory was re-established at the Sorbonne, and in 1868 was removed to the École Centrale.

The political episode of Dumas's life was the natural result of an active mind with wide sympathies, which recognizes in the pressing demands of society its highest duties. The political and social upheaval of 1848 seemed at the time to endanger the stability in France of everything which a cultivated and learned man holds most dear; and Dumas was not one to consider his own preferences when he felt he could aid in averting the calamities which threatened his country. Immediately after the Revolution of February, he accepted a seat in the Legislative Assembly offered him by the electors of the Arrondissement of Valenciennes. Shortly afterwards the President of the Republic called him to fill the office of Minister of Agriculture and Commerce. During the Second Empire he was elevated to the rank of Senator, and shortly after his entrance into the Senate he became Vice-President of the High Council of Education. In order to reform the abuses into which many of the higher educational institutions of Paris had fallen, he accepted a place in the Municipal Council of Paris, over which he subsequently presided from 1859 to 1870.

In 1868 Dumas was appointed Master of the Mint of France, but he retained the office only during a short time, for with the fall of the Second Empire, in 1870, his political career came to an abrupt termination. The Senate had ceased to exist, and in the stormy days which followed, the Municipal Council had naturally changed its complexion; and even at the Mint, the man who had held such a conspicuous position under the Imperial government was obliged to vacate his place. Some years previously he had resigned his professorships because his official positions were incompatible with his relations as teacher, and now, at the age of seventy, he found himself for the first time relieved from the daily routine of official duties, and free to devote his leisure to the noble work of encouraging research, and thus promoting the advancement of science. He had reached an age when active investigation was almost an impossibility, but his commanding position gave him the opportunity of exerting a most powerful influence, and this he used with great effect. In early life he had been elected, in 1832, a member of the Academy of Sciences in succession to Serullas; in 1868 he had succeeded Flourens as its Permanent Secretary; and in 1875 he was elected a member of the French Academy as successor to Guizot, a distinction rarely attained by a man of science.

It was, however, as Permanent Secretary of the Academy of Sciences that Dumas exerted during the last years of his life his greatest influence. He was the central figure and the ruling spirit of this distinguished body. No important commission was complete without him, and on all public occasions he was the orator of the body, always felicitous, always eloquent. In announcing Dumas's death to the Academy, M. Rolland, the presiding officer, said: —

" Vous savez la part considérable que Dumas prenait à vos travaux et vous avez bien souvent admiré, comme moi, la haute intelligence et la tact infini avec lesquels il savait imprimer à nos discussions les formes modérées et courtoises inhérentes à sa nature et à son caractère. Sous ce rapport aussi la perte de Dumas est irréparable, et crée dans l'Académie un vide bien difficile à combler. Aussi, longtemps encore nous chercherons, à la place qu'il occupait au Bureau avec tant d'autorité, la figure sympathique et vénérée de notre bienaimé Secrétaire perpétuel."

And while Dumas was still occupying his conspicuous position in the Academy, one of the most distinguished of his German contemporaries * wrote of him: " An ever-ready interpreter of the researches of others, he always heightens the value of what he communicates by adding from the rich stores of his own experience, thus often conveying lights not noticed even by the authors of those researches."

When the writer last saw Dumas, in the winter of 1881-82, the great chemist had still all the vivacity of youth, and it was

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* A. W. Hofmann, in Nature, February 6, 1880, to whose admirable and extended biography the writer is indebted for much of the material with which this notice has been prepared.

difficult to realize his age. He took a lively interest in all questions of chemical philosophy, which he discussed with great earnestness and warmth. There was the same fire and the same exuberance of fancy which had enchanted me in his lectures thirty years before. At an age when most men hold speculation in small esteem, I was much struck with his criticism of a contemporary, who, he said, had no imagination, although he spoke with the highest praise of his experimental skill. At that time Dumas showed no signs of impaired strength. But during the following year his health began to fail, and he died on the 11th of April, at Cannes, where he had sought a retreat from the severity of the winter climate of Paris.

Dumas was one of the few men whose greatness cannot be estimated from a single point of veiw. He was not only eminent as an investigator of nature, but even more eminent as a teacher and an administrator. Beginning the study of chemistry at the culmination of the epoch of the Lavoisierian system, and regarding, as he always did, the author of that system with the greatest admiration, he nevertheless was the first to discover the weak point in its armor and inflict the wound which led to its overthrow. Without attempting to detail Dumas's numerous contributions to chemical knowledge, we will here only refer to three important investigations, which produced a marked influence in the progress of chemical science.

While still in Geneva, Dumas, as has been said, made numerous determinations of the densities of allied substances, with a view to discovering the relations of what he called their molecular or atomic volumes; and it is no wonder to us that the problem proved too complex to be solved at that time. After his removal to Paris he took up the much simpler problem which the relations of the molecular volumes of aeriform substances present, and his paper "On Some Points of the Atomic Theory," which was published in the *Annales de Chimie et de Physique* for 1826, had an important influence in developing our modern chemical philosophy. Gay-Lussac had previously observed, that not only the relative weights of the several factors and products concerned in a chemical process bear to each other definite proportions, but also, when the materials are aeriform, the relative volumes preserve an equally definite and still simpler ratio. Moreover, on the physical side, Avogadro, and afterwards Ampère, had conceived the theory, that in the state of gas all molecules must have the same volume. It was Dumas who first saw that these principles furnished an important means of verifying the molecular and atomic weights.

"I am engaged," he writes, "in a series of experiments intended to fix the atomic weights of a considerable number of bodies, by determining their density in the state of gas or vapor. There remains in this case but one hypothesis to be made, which is accepted by all physicists. It consists in supposing that, in all elastic fluids observed under the same conditions, the molecules are placed at equal distances, i. e. that they are present in them in equal numbers. An immediate consequence of this mode of looking at the question has already been the subject of a learned discussion on the part of Ampère,"—and Avogadro as the author subsequently adds,—"to which, however, chemists, with the exception perhaps of M. Gay-Lussac, appear to have given as yet but little attention. It consists in the necessity of considering the molecules of the simplest gases as capable of a further division,—a division occurring in the moment of combination, and varying with the nature of the compound."

Here, it is obvious, are the very conceptions which form the basis of our modern chemical philosophy; and at first we are surprised that they did not lead Dumas at once to the full realization of the consequences which the doctrine of equal molecular volumes involves in the interpretation of the constitution of chemical compounds, and to the clear distinction between "the physical smallest particles" and "the chemically smallest particles," or the molecules and the atoms, as we now call the physical and the chemical units. This distinction is implied throughout Dumas's paper already quoted, and is illustrated by a striking example in the introduction to his treatise on "Chemistry applied to the Arts," published two years later; but the ground was not yet prepared to receive the seed, and more than a quarter of a century must pass before the full harvest of this fruitful hypothesis could be reaped.

There were, however, two important incidental results of this investigation from which chemical science immediately profited. One was a simple method of determining with accuracy the vapor densities of volatile substances which has since been known by Dumas's name. The other was a radical change in the formula of the silicates. On the authority of Berzelius, who based his opinion chiefly on the analogy between the silicates and the sulphates, the formula SiO_3 had been accepted as representing the constitution of silica. But from the density of both the chloride and the fluoride of silicon Dumas concluded that the formula was SiO_2, a conclusion which is now seen to be in complete harmony with the scheme of allied compounds. To Berzelius, however, the new views appeared wholly out of harmony with the system of chemistry which he had so greatly assisted in developing, and he opposed them with the whole weight of his powerful influence, and so far succeeded as to prevent their general adoption for many years.

Still, "the new mode of looking at the constitution of silicic acid slowly but surely gained ground, and it is now so firmly rooted in our convictions, that the younger generation of chemists will scarcely understand the pertinacity with which this innovation was resisted."*

But if this investigation of gas and vapor densities brought a great strain upon the dualistic system, the second of the three great investigations of Dumas, to which we have referred, led to its complete overthrow. The experimental results of this investigation would not be regarded at the present day as remarkable, and cannot be compared either in breadth or intricacy with the results of numerous investigations of a similar character which have since been made. The most important of these results were the substitution products obtained by the action of chlorine gas on acetic acid. They were published in a series of papers entitled "Sur les Types Chimiques," and the capital point made was that chlorine could be substituted in acetic acid for a large part of the hydrogen without destroying the acid relations of the products; and the inference was, that the qualities of a compound substance depend not simply on the nature of the elements of which it consists, but also on the manner or type according to which the elements are combined.

To the chemists of the present day these results and inferences seem so natural that it is difficult to understand the spirit with which they were received forty years ago. But it must be remembered that at that time the conceptions of chemists were wholly moulded in the dualistic system. It was thought that chemical action depended upon the antagonism between metals and metalloids, bases and acids, acid salts and basic salts, and that the qualities of the products resulted from the blending of such opposite virtues. That chlorine should unite with hydrogen was natural, for no two substances could be more unlike; but that chlorine should supply the place of hydrogen in a chemical compound was a conception which the dualists scouted as absurd. Even Liebig, the "father of Organic Chemistry," warmly controverted the interpretation which Dumas had given to the facts he had discovered. Liebig himself had successfully investigated the chemical relations of a similar class of organic products. He had, however, worked on the lines of the dualistic system, showing that organic substances might be classed with similar inorganic substances, if we assume that certain groups of atoms, which he called "compound radicals," might take the place of elementary substances. In the edition of the organic part of Turner's Chemistry bearing his name, Organic Chemistry is defined as the "Chemistry of Compound Radicals," and the formulæ of organic compounds are represented on the dualistic system. Liebig's conceptions were therefore naturally opposed to those advanced by Dumas, but it is pleasant to know that the controversy which arose never disturbed the friendly relations between these two noble men of science, who could approach the same truth from different sides, and yet have faith that each was working for the same great end. In his commemorative address on Pelouze, Dumas expresses toward Liebig sentiments of affectionate regard, and Liebig dedicates to Dumas, with equal warmth, the German edition of his "Letters on Chemistry."

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* Hofmann, *loc. cit.*

By the second investigation, as by the first, although Dumas gave a most fruitful conception to chemistry, he only took the first step in developing it. His conception of chemical types was very indefinite, and Laurent wrote of it, a few years later: "Dumas's theory is too general; by its poetic coloring, it lends itself to false interpretations; it is a programme of which we await the realization." Laurent himself helped towards this realization, and in his early death left the work to his associate and friend Gerhardt, who pushed it forward with great zeal, classifying chemical compounds according to the four types of hydrochloric acid, water, ammonia and marsh gas. Hofmann, Williamson, Wurtz, and many others, greatly aided in this work by realizing many of the possibilities which these types suggested; and thus modern Structural Chemistry gradually grew up, in which the types of Dumas and Gerhardt have been in their turn superseded by the larger views which the doctrine of quantivalence has opened out to the scientific imagination. It is a singular fact, however, that, while the growth began in France, the harvest has been chiefly reaped by Germans; and that, although in its inception the movement was strongly opposed in Germany, its legitimate conclusions are now repudiated by the most influential school of French chemists.

The third great investigation of Dumas was his revision of the atomic weights of many of the chemical elements, and in none of his work did he show greater experimental skill. His determination of the atomic weight of oxygen by the synthesis of water, and of that of carbon by the synthesis of carbonic dioxide, are models of quantitative experimental work. To this investigation, as to all his other work, Dumas was directed by his vivid scientific imagination. In his teaching, from the first, he had aimed to exhibit the relations of the elementary substances by classing them in groups of allied bodies; and at the meeting of the British Association in 1851 he had delighted the chemical section by the eloquence and force with which he exhibited such relations, especially triads of elementary substances; such as chlorine, bromine and iodine; oxygen, sulphur and selenium; phosphorus, arsenic and antimony; calcium, barium and strontium; in which not only the atomic weight, but also the qualities of the middle member of the triad, were the mean of those of the other two members. Later, he came to regard these triads as parts of more extended series, in each of which the atomic weights increased from the first to the last element of the series, by determinate, but not always by equal differences, the values being, if not exact multiples of the hydrogen atom according to the hypothesis of Prout, at least multiples of one half or one quarter of that weight. There can be no doubt that these speculations were more fanciful than sound, and that Dumas did not do full justice to earlier theories of the same kind; but with him these speculations were merely the ornaments, not the substance of his work, and they led him to fix more accurately the constants of chemistry, and thus to lay a trustworthy foundation upon which the superstructure of science could safely be built.

That exuberance of fancy to which we have referred made Dumas one of the most successful of teachers, and one of the most fascinating of lecturers. It was the privilege of the writer to attend the larger part of two of his courses of lectures given in Paris in the winters of 1848 and 1851, and he remembers distinctly the impression produced. Besides the well-arranged material and the carefully prepared experiments, there was an elegance and pomp of circumstance which added greatly to the effect. The large theatre of the Sorbonne was filled to overflowing long before the hour. The lecturer always entered at the exact moment, in full evening dress, and held to the end of a two hours' lecture the unflagging attention of his audience. The manipulations were entirely left to the care of a number of assistants, who brought each experiment to a conclusion at the exact moment when the illustration was required. An elegance of diction, an appropriateness of illustration, and a beauty of exposition, which could not be excelled, were displayed throughout, and the enthusiasm of a French audience added to the animation of the scene.

To the writer the lectures of Dumas were brought in contrast to those of Faraday. Both were perfect of their kind, but very different. Faraday's method was far more simple and natural, and he excelled Dumas in bringing home to young minds abstruse truths by the logic of well arranged consecutive experiment. With Dumas there was no attempt to popularize science: he excelled in clearness and elegance of exposition. He exhausted the subject which he treated, and was able to throw a glow of interest around details which by most teachers would have been made dry and profitless.

Two volumes of Dumas's Lectures have been published;

one comprises his course on the Philosophy of Chemistry, delivered at the College of France in 1836; the other contains only a single lecture, accompanied by notes, entitled "The Balance of Organic Life," which was delivered at the Medical School of Paris, August 20, 1841. In both these volumes will be found the beauty of exposition and the elegance of diction of which we have spoken, and they are models of literary style. But of course the sympathetic enthusiasm of the great man's presence cannot be reproduced by written words.

The lecture on "The Balance of Organic Life" was probably the most remarkable of Dumas's literary efforts. It dealt simply with the relations that the vegetable sustains to the animal kingdom through the atmosphere, which, though now so familiar, were then not generally understood; and the late Dr. Jeffries Wyman, who heard the lecture, always spoke of it with the greatest enthusiasm.

As might be expected, Dumas's oratory found an ample field in the Chamber of Deputies and in the Senate; and whether setting forth a project of recasting the copper coinage or a law of drainage, or ridiculing the absurd theories of homeopathy, he riveted the attention of his colleagues as completely as he had entranced the students at the Sorbonne.

In the early part of his life, Dumas was a voluminous writer, and in 1828 published the "Traité de Chimie appliquée aux Arts," in eight large octavo volumes, with an atlas of plates in quarto. But besides this extended treatise, the two volumes of Lectures just referred to are his only important literary works. He published numerous papers in scientific journals, which, as we have seen, produced a most marked effect on the growth of chemical science. But the number of his monographs is not large compared with those of many of his contemporaries, and his work is to be judged by its importance and influence rather than by the extent of the field which it covers.

In his capacity of President of the Municipal Council at Paris, of Minister of Agriculture and Commerce, of Vice-President of the High Council of Education, and of Perpetual Secretary of the Academy of Sciences, Dumas had abundant opportunity for the exercise of his administrative ability, and no one has questioned his great powers in this direction; but in regard to his political career we could not expect the same unanimity of opinion. That he was a liberal under Louis Philippe, and a reactionist under Louis Napoleon, may possibly be reconciled with a fixed political faith and an unswerving aim for the public good; but his scheme for "civilian billetting" (by which wealthy people having rooms to spare in their houses would have been compelled to billet artisans employed in public works) leads one to infer that his statesmanship was not equal to his science. Nevertheless, there can be no question about his large-hearted charity. He instituted the "Crédit Foncier," which flourishes in great prosperity to this day; he also founded the "Caisse de Rétraite pour la Vieillesse," and several other agricultural charities, which, though less successful, afford great assistance to aged workmen. Louis Napoleon used to say in jest that the whole of the War Minister's budget would not have been enough to realize M. Dumas's benevolent schemes; and once, half dazzled, half amused, by one of the chemist's vast sanitary projects, he called him the " the poet of hygiene."

It was to be expected that a man working with such eminent success in so many spheres of activity, and at one of the chief centers of the world's culture, should be loaded with medals, and marks of distinction of every kind. It would be idle to enumerate the orders of knighthood, or the learned societies, to which he belonged, for, so far from their honoring him, he honored them in accepting their membership. It is a pleasure, however, to remember that he lived to realize his highest ambitions and to enjoy the fruits of his well-earned renown. France has added his name in the Pantheon

"AUX GRANDS HOMMES LA PATRIE RECONNAISSANTE."

ART. XXXVIII.—*A New Meteorite;* by I. R. EASTMAN.

WHILE staying over Sunday in the city of Grand Rapids, Mich., in September 1883, I saw in a local newspaper a reference to a strange, heavy, metallic mass which was to be seen in the store of Mr. C. G. Pulcher. Early Monday morning I found the store and immediately recognized the meteoric character of the mass.

It was roughly pear-shaped, 14 inches long and 9·6 inches in diameter at the thickest part, and weighed 114 lbs.

It was discovered about May 15, 1883, by Michael Clancy, a contractor, while making an excavation for building purposes on land belonging to the Catholic Church in Grand Rapids. It was found about three feet below the natural surface of the ground wedged between two large bowlders and was removed with considerable difficulty. The finder feeling certain that he had secured a valuable prize kept his secret for some weeks and expended much time and labor with hammer and cold chisel in the attempt to cut off the smaller end. He succeeded, however, only in mutilating the unusually fine specimen by cutting a groove about three-sixteenths of an inch deep quite around the mass and six inches from the smaller end.

Mr. Pulcher could not then be induced to part with the mass but I finally secured a few grains in weight, from the bur left by the chisel, from which Mr. F. W. Taylor of the Smithsonian Institution made a preliminary analysis with the following result:

Weight of specimen submitted to analysis 24 grains.

Analysis.

Iron	94·543
Nickel	3·815
Cobalt	0·396
Insoluble residue	0·118

The fragment was somewhat oxidized which accounts in part for the shortage. The entire specimen is now in the Smithsonian Institution for examination and analysis.

U. S. N. Observatory, August 26, 1884.

SCIENTIFIC INTELLIGENCE.

I. SCIENTIFIC ASSOCIATIONS.

1. *The British Association.*—The fifty-fourth meeting of the British Association, which opened in Montreal on the 27th of August and closed on the 3d of September, was a notable one in many respects. In the first place, it was the first meeting ever held beyond the limits of Great Britain; and it was not without many misgivings that the experiment was tried. Its success reflects great credit upon the management and must be gratifying to all concerned. Between 800 and 900 members crossed the Atlantic in order to be present; and the courtesy of temporary membership accorded to the Fellows of the American Association largely increased the number in attendance. Moreover, the number of persons who formally joined the Association at Montreal, either as members or as associates, was very large, having been stated as between 1400 and 1500.

In the next place, the addresses delivered were of exceptional excellence. After a few words of welcome from the Governor-General, Lord Lansdowne — in which he gracefully mentioned that the honor of knighthood had been conferred by the Queen upon Principal Dawson—Sir Wm. Thomson, acting for Professor Cayley, the President, introduced the incoming President, Lord Rayleigh. The subject of his address was "Recent progress in physics." Two quotations may be made from the concluding portion: "In speaking unfavorably of superfluous hypothesis," he says, "let me not be misunderstood. Science is nothing without generalizations. Detached and ill-assorted facts are only raw material, and in the absence of a theoretical solvent, have but little nutritive value. At the present time and in some departnts the accumulation of material is so rapid that there is ger of indigestion. By a fiction as remarkable as any to be nd in law, what has once been published, even though it be in Russian language, is usually spoken of as 'known' and it is en forgotten that the rediscovery in the library may be a more ficult and uncertain process than the first discovery in the lab-tory. . . . . If, as is sometimes supposed, science consisted in hing but the laborious accumulation of facts, it would soon ne to a standstill, crushed as it were under it own weight. e suggestion of a new idea, or the detection of a law, super-les much that had previously been a burden on the memory, l by introducing order and coherence facilitates the retention the remainder in an available form. . . . . Two processes are is at work side by side, the reception of new material and the gestion and assimilation of the old. . . . . The work which serves, but I am afraid does not always receive the most credit, hat in which discovery and explanation go hand in hand, in ich not only are new facts presented but their relation to old s pointed out." Again, referring to educational systems, rd Rayleigh says: "From the general spread of a more scien-c education we are warranted in expecting important results. st as there are some brilliant literary men with an inability or least a distaste practically amounting to inability for scientific as, so there are a few with scientific tastes whose imaginations never touched by merely literary studies. To save these m intellectual stagnation during several important years of ir lives is something gained; but the thorough going advo-es of scientific education aim at much more. To them it pears strange and almost monstrous that the dead languages uld hold the place they do in general education; and it can rdly be denied that their supremacy is the result of routine her than of argument. . . . . It is useless to discuss the ques-n upon the supposition that the majority of boys attain either a knowledge of the languages or to an appreciation of the itings of the ancient authors. The contrary is notoriously the th; and the defenders of the existing system usually take ir stand upon the excellence of its discipline. From this point view there is something to be said. The laziest boy must rt himself a little in puzzling out a sentence with grammar l dictionary, while instruction and supervision are easy to ganize and not too costly. But when the case is stated plainly r will agree that we can afford so entirely to disregard results. . . I believe that French and German if properly taught, ich I admit they rarely are at present, would go far to replace tin and Greek from a disciplinary point of view, while the ual value of the acquisition would in the majority of cases be omparably greater. In half the time usually devoted without cess to the classical languages, most boys could acquire a lly serviceable knowledge of French and German."

Professor Sir Wm. Thomson, President of the Physical Section entitled his address, "Steps toward a kinetic theory of matter," discussing in it, in his masterly and suggestive way, the manner in which the properties of matter, especially elasticity, may be accounted for on the kinetic theory. Sir Henry E. Roscoe, as President of the Chemical Section, reviewed with great ability the progress of chemical theory, from the death of Berzelius, in 1848, to the present, and closed with a valuable discussion of the physical questions now pressing on the chemist. Mr. W. T. Blanford addressed the Geological Section on the "Correlations of geological formations;" Professor Moseley the Biological Section, on "The physiology of deep-sea life;" General Sir J. H. Lefroy, the Geographical Section, on "Recent geographical discovery;" Sir Richard Temple, the Section of Economic Science and Statistics, on "The general statistics of the British Empire;" Sir Fredk. J. Bramwell, the Mechanical Section, on "The relation of mechanical science to other sciences," and Dr. E. B. Tylor, the Anthropological Section, on "Some American aspects of anthropology."

Again, the character of the papers presented was in general of a high order. Among the most important of those read in the Physical Section may be mentioned those by Lord Rayleigh, "A lecture experiment on induction," "On telephoning through a cable," "On a galvanometer with twenty wires," "On the colors of thin plates," and "On Clark's standard cells;" by Sir Wm. Thomson, "On a gyrostatic working model of the magnetic compass," and "On safety fuses for electric circuits;" by Professor Dewar, on "The law of total radiation at high temperatures;" by J. T. Bottomley, "On loss of heat by radiation and convection as affected by dimensions of the cooling body and on cooling in a vacuum;" by Professor Shuster, "On the influence of magnetism on the discharge of electricity through gases;" by Professor Fitzgerald, "On an analogy between heat and electricity;" by Professor Rowland, on "Recent progress in photographing the solar spectrum," and Rev. S. J. Perry, "On the spot-spectrum from D to B;" by Professor Chandler Roberts, "On the diffusion of metals;" by Professor Michelson, on "The velocity of light in carbon disulphide and the difference of the velocities of red and blue light in the same;" by W. H. Preece, "On the law regulating the connection between current and intensity of incandescence of carbon filaments in glow lamps;" and by Professor S. P. Thompson, on "The equations of dynamo-electric machines."

Among the papers of note in the Chemical Section were those by Dr. Wolcott Gibbs, "On complex inorganic acids;" by Sir Henry Roscoe, "On the diamondiferous deposits of South Africa;" by Professors Liveing and Dewar, "Spectroscopic studies of explosions;" by Professor Dewar, "On the liquefaction of oxygen and on the density of liquid hydrogen;" by Mr. H. B Dixon, "Experiments on gaseous combustion," and "On the velocity of explosions in gases;" by Dr. W. H. Perkin, "On the magnetic rotation of compounds in relation to their chemical composition," and "On coal-tar coloring matters;" by Dr. J. H. Gladstone, "On the present state of our knowledge of refraction equivalents;" by Professor Frankland, "On the chemical aspect of the storage of energy;" and by Professor Tilden, "On some phenomena of solution."

Two excellent features of the sectional work should be noted. The first is the discussion of fundamental questions. In the Physical Section, the subjects discussed were: "The seat of the electromotive forces in the voltaic cell," the discussion being opened by Professor O. J. Lodge, who took ground against the contact theory; and "The connexion of sun-spots with terrestrial phenomena," opened by Professor A. Shuster. In the Chemical Section Professor Dewar opened the discussion "On the constitution of the elements" and Professor Frankland the discussion "On chemical changes in their relation to micro-organisms." The second feature is the special reports presented to the sections. The Physical Section received the reports of Committees on electric standards, on the harmonic analysis of tidal observations, on tidal observations in the English Channel, on the measurement of solar radiation, on meteoric dust, and on facilitating the adoption of the metric system in Great Britain. Reports of Committees to the Chemical Section were made by Professor Chandler Roberts "On spectrum analysis;" and by Mr. H. B. Dixon on "Chemical nomenclature."

Nor was the social element forgotten at the Montreal meeting. The transatlantic members were treated most liberally by the government railroads, especially the Canadian Pacific, which granted them free transportation to its western terminus. On Saturday, the 30th, excursions were made to Quebec, to Ottawa, and to Lake Memphremagog. And at the close of the meeting a select party of 150 was taken to the Rocky Mountains and another of 300 to Toronto, by the Canadian Pacific. Private hospitality was offered abundantly; and dinners, receptions and lawn parties were numerous. The weather was delightful and the social success of the meeting was equal to the scientific one. G. F. B.

2. *The American Association.*—The Philadelphia meeting of the American Association may justly be put on record as the largest and most successful in its history. Whether measured by the number of members in attendance, which reached the unprecedented figure of 1249, by the number of added members, given as 491, by the number of papers presented, 345 as recorded on the Secretary's list, on the one hand; or by the quality of the meeting, the unusual number of eminent men present, both from this country and Europe, and the high character of the papers presented, on the other; the general verdict seems to be unanimous in placing this meeting as exceptionally large and interesting.

The meeting opened on Thursday morning, Sept. 4th, in the Academy of Music, Professor Young resigning the Presidency to

Professor Lesley, and speeches of welcome being delivered by Governor Pattison and Mayor Smith. In the afternoon, the Vice Presidents delivered their addresses to the respective sections. Professor Eddy, in Section A, took for his subject "The present state of mathematical training in our colleges; its aims, its needs and its relations to education and to scientific research." To Section B, Professor Trowbridge discoursed upon "What is Electricity," hoping thereby to make his audience ask themselves the question with more humility and a greater consciousness of ignorance. "We shall probably never know," he says "what electricity is, any more than we shall know what energy is. What we shall be able, probably, to discover, is the relationship between electricity, magnetism, light, heat, gravitation and the attracting force which manifests itself in chemical changes." Professor J. W. Langley, in addressing Section C, took "Chemical Affinity" as his subject, considering the thermal, the electrical, and the time methods of studying it. Professor Thurston spoke to Section D on "The mission of science;" Professor Winchell to Section E on "The crystalline rocks of the northwest;" Professor Cope to Section F on "Catagenesis, or creation by retrograde metamorphosis of energy;" Professor Morse to Section H on "Man in the Tertiaries;" and Gen. John Eaton to Section I on "Scientific methods and scientific knowledge in common affairs."

The address of the retiring President, Professor Young, was delivered in the Academy of Music on Friday evening. He selected as his subject "Some of the pending problems in astronomy," discussing, in his clear, thoughtful and able way, those questions, in the first place, "which seem to be most pressing and which most urgently require solution as a condition of advance;" and, in the second, "which appear in themselves most interesting or likely to be fruitful from a philosophic point of view." The first to be considered were, "the questions which relate to the dimensions and figure of the earth, the uniformity of its diurnal rotation and the constancy of its poles and axis." The earth's dimensions are so uncertain as to produce serious embarassment in the reduction and comparison of certain lunar observations. "As to the form of the earth" he says, "it seems pretty evident that before long it will be wise to give up further attempts to determine exactly what spheroid or ellipsoid most nearly corresponds to the actual figure of the earth. . . . It will be better to assume some closely approximate spheroid as a finality; its elements to be forever retained unchanged, while the deviations of the actual surface from this ideal standard will be the subject of continued investigation and measurement." As to the uniformity of the earth's rotation, Professor Young says, "The time must unquestionably come when the accuracy of scientific observation will be so far increased, that the irregularities of the earth's rotation, produced by the causes alluded to a few minutes ago, will protrude and become intolerable. Then a new unit of time will have to be found for scientific purposes, founded perhaps, as has been already suggested by many physicists, upon the vibrations or motion of light or upon some other physical action which pervades the universe." The address passes next to the moon and considers the unsatisfactory condition of the lunar theory; to the planets and discusses the accordance of theory with observation in their motions, expressing the opinion that "the tremendous array of negative evidence from the most trustworthy observers, with the best equipment and opportunity, makes it little short of certain that there is no Vulcan in the planetary system;" to the sun itself, giving a masterly statement of the difficulties yet unconquered in the theory of his constitution; to comets, "those strange objects of such enormous volume and inconceivable tenuity, self-luminous and transparent, yet reflecting light, the seat of forces and phenomena unparalleled in all our other experience;" and finally to the problems of stellar astronomy; closing with a few well chosen words upon the advantages of the study of truth for its own sake, since "in the investigation and discovery of the secrets and mysteries of the heavens the human intellect finds most invigorating exercise and most nourishing and growth-making aliment."

Of the papers read, it will, of course, be impossible to speak in detail. Those communicated to Section A numbered 37, those to Section B 42, and those to Section C 29. Among the physical papers, those of Professor Mendenhall "On the variation of the resistance of carbon under pressure;" of Professor W. A. Rogers "Additional observations confirming the relation: Metre des Archives = Imperial yard + 3·37027 inches;" by Professor W. H. Pickering "Photography of the infra-red region of the spectrum;" of Professor Carhart "Relation of the electromotive force of a Daniell cell and the strength of the zinc sulphate solution;" of Dr. W. Thomson "Method for the practical examination of railway employees as to color blindness, acuteness of vision and hearing; with the results obtained by it on the Pennsylvania railroad;" of Professor Harrington "Notes on Aneroids;" of Professor Graham Bell "On a possible method of electrical communication between vessels at sea;" of Professor E. H. Hall "On the magnetic rotation of the equipotential lines of electric currents in various metals and alloys;" of Professor Wead "On the intensity of sound, and the energy used by an organ pipe," may be mentioned. Among the other papers of interest read in the section of chemistry, those of Dr. Springer on "Torsion balances;" of Professor Wiley "Optical methods of estimating sugar in milk;" of Professor Atwater "On the assimilation of atmospheric nitrogen by plants;" of Professor Langley "An explanation of Gladstone and Tribe's 2–3 law in chemical dynamics;" and of Miss Abbott "Preliminary analysis of the bark of *Fouquieria splendens* Engl." may be specified.

The number of members of the British Association present at Philadelphia was gratifyingly large. A special train from Montreal to Philadelphia on Thursday brought about 200; and more than a hundred came by other routes. They were made honorary members of the American Association, and many of them took an active part in the work of the sections. Among the papers thus presented may be mentioned those by Professor Sir Wm. Thomson "On the distribution of potential in conductors experiencing the electromagnetic effects discovered by Hall;" by Professor James Dewar on "Electric discharges in relation to the equilibrium of gaseous atmospheres" and "The density of solid carbonic acid;" by Professor J. C. Adams "On the general expression for the value of the obliquity of the ecliptic at any given time, taking into account terms of the second order," and "Note on Newton's theory of atmospheric refraction and on his method of finding the motion of the moon's apogee;" by Professor A. Vernon Harcourt "On the minute study of chemical change" and "On a lamp for producing a constant flame;" by Sir Frederick Bramwell on "Heating from a central source;" by Rev. S. J. Perry, on "Late researches on the solar surface with special reference to evanescent spots;" by Professor Robert S. Ball, exhibiting and describing a model of the "ruled cubic surface known as the cylindroid;" by Professor H. N. Moseley "On the presence of eyes and other sense organs on the shells of Chitonidæ," "Utricularia vulgaris with young teleostean fishes entrapped in the bladder-trap of that plant" and "On the feathers of the Dodo;" by Dr. E. B. Tylor "Remarks on North American races and civilization;" by Professor J. G. McKendrick "On ethidene dichloride as an anæsthetic." Papers were read also by Capt. Bedford Pim, J. Biddulph Martin, Professors W. F. Barrett, S. P. Thompson, H. Hennessey, Valentine Ball and A. H. Allen, and Mr. Trelawney Saunders.

The introduction of subjects for discussion by the sections constituted a new and valuable feature of the meeting. Through the efforts of Professor J. W. Langley, its Vice President, Section C had three discussions. The first was on "Valence," and was opened by Professor F. W. Clarke; the second was on "Fermentation," and was opened by Dr. Alfred Springer; the third was on "Educational methods in laboratory practice and in the illustration of chemical lectures," opened by Professor Remsen. Section D discussed on Monday, "The use and value of accurate standards, screws, surfaces, gauges, etc.;" and on Wednesday, "The applications of electricity."

Lectures were delivered at the Academy of Music on Thursday evening by Professor J. S. Newberry of New York on "The geological evolution of the North American continent," and on Tuesday evening by Professor Robert Stawell Ball, Astronomer Royal for Ireland, on "Recent researches on the distances of the stars." Both lectures were illustrated with the lantern.

The social festivities of the meeting were given on a magnificent scale. On Friday evening, before Professor Young's address, the American Association was welcomed by President Welsh of the Local Committee, and the British Association by Provost Pepper

' the University of Pennsylvania on behalf of the citizens of hiladelphia. After the address the Academy of Music was rown open for a grand promenade concert and reception for the mainder of the evening. On Tuesday evening the Local Com-ittee gave a brilliant reception at the Academy of Fine Arts, nd on Wednesday afternoon the Ladies' Reception Committee ave a charming Lawn Party on the grounds of Haverford ollege. On Monday afternoon receptions were given by the ocal Committee, Trustees and Faculty at the University of ennsylvania, by the Women's Medical College, by the Zoo-gical Gardens to witness Mr. Muybridge's instantaneous pho-graphic work, and by the Botanical section of the Academy f Natural Sciences.

The excursions, moreover, were on an exceedingly liberal scale. he Pennsylvania railroad gave three excursions to the seashore, iz: to Long Branch, to Cape May and to Atlantic City. The hiladelphia & Reading railroad gave an excursion to the anthra-te coal regions. All of these were well patronized, especially le latter, which numbered about 400, including some members ' the American Institute of Mining Engineers. Under the excel-nt guidance of Mr. Ashburner, of the State Geological Survey, le day was most pleasantly spent. Other minor excursions were rganized to inspect the local geology and the local botany of 'hiladelphia.

The city of William Penn has fully sustained the reputation for ounteous hospitality which it acquired a century ago and has ver since maintained. Unfortunately the heat during the meet-ig was intense, and made a burden of many a pleasure. But in pite of the high temperature, the second meeting of the Amer-an Association at Philadelphia will ever remain a bright and leasant memory. G. F. B.

II. PHYSICS.

1. *Papers read before the Physical Section at the meeting of le American Association for the Advancement of Science at 'hiladelphia.*—The papers read before the Physical section of le American Association for the Advancement of Science at the 'hiladelphia meeting have covered a varied field. The growing nterest in and importance of photography were shown by papers om Mr. W. H. Pickering on the use of dry plates in photo-raphing the infra red, in which he showed that it was compara-ively easy to photograph far into this region by such plates. A iscussion upon this subject was carried on in which Professor Rowland stated his opinion that time was an important element n such work. Professor Abney by his emulsions could obtain hotographs in ten minutes. Professor Rowland spoke of his xperience in photographing the solar spectrum with his new ratings, and expressed his conviction that special emulsions nust be prepared for the work and that reliance could not be placed upon dry plates obtained from the manufacturers for

work in the infra red. Mr. Hough described a new form of Sensitometer for use in photography. Mr. Nichols read a paper on a Spectrophotometer for studying the intensity of light reflected from various pigments and gave a method by means of which the observations could be reduced to absolute measure. The instrument consisted of a spectroscope provided with a Nicols prism and a totally reflecting prism. The intensity of the spectrum could be reduced known amounts by the Nicols prism, and the reflecting prism allowed the light reflected from the pigment to be compared with the proper portion of the solar spectrum. Mr. Nichols stated that he had found that the eyes of men in general were more sensitive to shades of color than those of women. Professor Carhart read the results of observations made in the Physical Laboratory of Berlin on the electromotive force of a Daniell cell with sulphate of zinc of varying density. His results show that this cell under certain conditions is very constant and can serve as a practical measure of electromotive forces in general. Mr. Hazen, of the United States Signal Service, gave a description of a proposed statistical method of studying the frequency and character of thunder storms, and showed the probability of a connection between the path of these storms and the regions of low barometric pressure. Professor Abbe of the Signal Service, in remarks upon this paper, commended in general the kind of work undertaken by Mr. Hazen. It was recommended by Professor Abbe that the name of the section should be so changed as to include the discussion of papers on terrestrial physics. This change was referred to the Standing Committee of the Association. A temporary subsection of section B was then formed, before which Professor Abbe presented various papers on seismology and the systematization of observation of temperature and electricity. The most noteworthy discussion that occurred was on the Hall Phenomenon. Mr. E. H. Hall read a paper on this subject, in which he referred to certain explanations of the phenomenon given by Mr. Shelford Bidwell, of Great Britain, and showed that they were not well grounded. Professor Sylvanus P. Thompson defended Mr. Bidwell and also described certain experiments of his own which he thought conclusively showed that it had not been proved by Mr. Hall that there is an electromotive force acting in a magnetic field at right angles to the direction of an electrical current passing through such a field. Sir William Thomson then took the floor and showed that the theory of electromagnetism demanded an effect of the nature discovered by Mr. Hall, and also said that many years ago he discovered certain equations in which the Hall phenomena "*lurked*," and he regarded Mr. Hall's paper as the most important contribution to the subject of magnetism which had appeared for many years. Sir William Thomson then gave a mechanical representation of the phenomenon. A paper by Mr. Loudon on the theory of thick lenses contained some interesting geometrical constructions.

J. T.

2. *Magnetic Polarity and Neutrality;* by Professor D. E. UGHES, F.R.S.—The following paragraphs are from the begining and close of a paper by Professor D. E. Hughes in the Proeedings of the Royal Society, No. 231:

"In recent papers upon the Theory of Magnetism,* I gave the pinion drawn from a long series of personal researches, that magietism in iron and steel is entirely due to the inherent polarity of ts molecules, the force of which could neither be destroyed nor ugmented; that, when we have evident magnetism, the moleules rotate so as to have all their similar polarities in one direcion; and that neutrality is a symmetrical arrangement or a alancing of polar forces, as in a closed circuit of mutual attracions. The series of researches which I now present bear unmisakable testimony to the truth of these views, showing the pposite polarities which exist in an apparently neutral bar of ron; and that it is by this means alone that external neutrality ccurs in the iron cores of an electro-magnet upon the cessation f the inducing current. * * *

"That inherent magnetic polarity is a quality of all matter, solid, iquid, gaseous, and the ether itself, varying only in degree and ot in nature, seems demonstrated by a series of researches I have een making upon the mechanism employed in magnetic conluction through the atmosphere and Crookes's vacuum.

"These researches are being made by means of the induction nd magnetic balance. They prove that the atmosphere, and resumably the ether as well as all liquids and gases, have their aturation point similar to iron, that the curve is the same as in erfect soft iron, and that the highest magnetic capacity of iron loes not exceed that of the atmosphere by more than forty imes; consequently we may fairly assume that the ether may be egarded as an extremely magnetic body, obeying the same laws s those of iron; and as I regard the symmetrical rotation of nagnetic molecules as the cause of evident magnetism in iron, and s the difference in force between iron, copper and ether is simply differential one, I believe that the neutrality which appears in ll paramagnetic and diamagnetic bodies, wherever the exciting nfluence is withdrawn, is formed by mutual molecular reactions roducing closed circuits of mutual attractions as demonstrated n iron.

"A line of force between a magnet and its armature is to me imply a line of molecular rotation; lines would neither be added or subtracted; they could simply be rotated from a symmetrical eutrality to an equal symmetrical point of saturation.

"In my paper upon the theory of magnetism, I showed that here were several molecular arrangements which produced xternal neutrality—the circular chain of molecules, when an lectric current passes through an iron wire, a neutrality produced y an artificial superposition of a weaker contrary magnetism upon one more internal—and made the supposition that were it possible to have a piece of iron free from the influence of the earth, then (if there had been no previous magnetization directing the structure) the molecules would short circuit their mutual attractions in the shortest path.

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* "Proc. Roy. Soc." (vol. 35, p. 178) and "Journal of the Society of Teleraph Engineers," vol. xii, 1883.

"The experiments cited in this paper are of an extremely simple nature, and after being verified by independent observers can no longer leave doubt as to the cause of neutrality.

"Whatever theory we adopt as an explanation of evident magnetism, it will be found that neutrality occurring after the cessation of an external inducing force upon a bar of iron or steel is the result of symmetrically opposed polar forces, producing apparent waves of opposite polarity, or reactions between the exterior and interior of a bar of iron."

3. *Report on the International Exhibition of Electricity held at Paris, August to November*, 1881; by Major DAVID PORTER HEAP, Corps of Engineers, U. S. A. 287 pp. 8vo. Washington, 1884 (Engineer Department, U. S. A.).—This volume contains brief descriptions of many of the electrical arrangements exhibited at the Paris Exhibition; these include many forms of batteries, dynamo and magneto electric machines, electro-motors, electric lamps, light houses and so on. The value of the descriptions given is increased by the fact that they are profusely illustrated. This publication has additional interest at the present moment in view of the similar exhibition now being held at Philadelphia.

4. *The Modern High Explosives.* Nitro-glycerine and Dynamite: their manufacture, their use and their application to mining and military engineering; Pyroxyline or Gun-cotton; the Fulminates, Picrates and Chlorates; also the chemistry and analysis of the elementary bodies which enter into the manufacture of the principal nitro-compounds; by MANUEL EISSLER, Mining Engineer. 395 pp. 8vo. New York, 1884 (John Wiley & Sons).—The title to this work, which has been quoted in full, is so comprehensive as to give a fair impression of its scope and value. In the treatment of the subject, it is divided into three parts; the first is devoted to the chemistry and analysis of the substances from which the high explosives are manufactured and the description of these explosives themselves; the second gives directions for the use of the high explosives, describing also the use of electricity in blasting operations; and the third gives the principles of blasting, the force and effect of explosive bodies, and many practical points bearing on mining and engineering problems, the explosions of mines, the destruction of walls, various obstructions as in navigation or in agriculture, and so on. The volume contains a large amount of useful information much needed in view of the constantly increasing use of high explosives, and the often comparative ignorance of those who handle them.

5. *Light;* by P. G. TAIT, M.A., etc. 276 pp. 12mo. Edinburgh, 1884 (Adam and Charles Black).—Professor Tait's excellent little treatise on Heat, noticed in a recent number of this

Journal (xxvii, 488) is now followed by a no less valuable companion volume on Light. This volume is the more welcome since contributions to the department of physics of which it treats, of a general nature, have been few in recent years, while there are numerous excellent volumes upon heat and electricity, adapted to the needs of all grades of students. This volume is elementary in character, and is especially suited to the private reading of a student to supplement the instruction of the class-room. It is fresh in matter and clear in style. A valuable feature, and one which is of necessity absent in class-room text-books, is to be found in the attention given to the historical development of the subject; numerous quotations from Newton, La Place, Huyghens and others are calculated to make clear to the student how the present accepted principles and theories have been reached.

III. Geology and Natural History.

1. *Professor James Hall on the "Hudson River" age of the Taconic slates.*—At the meetings of the American Association of Geologists and Naturalists (the antecedent of the present American Association) 40 to 45 years since, the age of the Taconic system was the subject of long discussions; and in the course of them Professor Hall advocated, in opposition to Professor Emmons, the Lower Silurian age of the Taconic slates and limestones, citing facts in proof from his own investigations. No paper on the subject was published by him, and not even a report of the discussions of the Association.

In connection with a recent letter, dated Albany, September 13, the writer has received from Professor Hall copies of two plates of sections prepared by him as early, he states, as 1845, exhibiting—as the result of his own studies—the positions of the rocks along four lines; one from Petersburgh, New York, eastward through the Taconic of Williamstown and Adams, Massachusetts; the *second*, 10 miles north of the first, through Hoosick and Mt. Anthony in the Taconic Range in Bennington; a *third* through Arlington and Equinox Mountain of the Taconic Range of Vermont; and a *fourth* still farther north, through Castleton and Rutland, Vermont. In the first-mentioned the limestone is made to underlie conformably, in a synclinal, the Taconic schists of Saddle Mountain and Graylock (as also shown by Emmons); in the *second*, Mt. Anthony is proved to be a broad synclinal of slates with limestone beneath; and in the third, Equinox Mountain is another synclinal of slate with underlying limestone—thus long anticipating in the exhibition of these broad synclinals, the similar sections of the Vermont Geological Report (1862). Underneath each section the limestone is stated to be of the age of the "Trenton and lower" formations, and the Taconic slates are made, as necessarily follows from the position of the limestone, of later Lower Silurian or the Hudson River group. The slates at Hoosick River had been previously proved to afford graptolites; and hence the limestone adjoining them and conformable in bedding with them was reasonably referred to the Lower Silurian. He writes that as to the precise period of the Hoosic slates, then made "Hudson River," he is at present uncertain.

At the Montreal meeting of the British Association Professor Hall expressed his belief in the synclinal character of Mt. Washington—the subject of the writer's paper at page 268 of this volume, and in the general synclinal character of the Taconic Range. J. D. D.

2. *Earthquakes of Ischia.*—The facts connected with the earthquakes of Ischia, from 1828 to 1883, and the theories brought forward in explanation, are discussed by Dr. Francis DuBois, in a paper published in vol. vii of the Transactions of the Seismological Society of Japan (p. 16, read Dec. 20, 1883). The following resumé of the facts and conclusions make the close of the paper:

Resumé.—What then do we really know about the Ischian earthquakes? Whatever is admitted by all or denied by none may be accepted as true.

All Ischian earthquakes of which any special record has been made resemble each other, in fact are a counterpart of one another, differing only in intensity, having a special type of which the following are the common and constant characteristics:

(1) If there are any premonitory signs one never hears of them until after the earthquake has taken place. There are always prophets after an event.

(2) Great suddenness; there is but one serious shock and all is over. Succeeding earthquakes are of very little importance.

(3) Extreme localization. There is not a gradually diminishing intensity of the seismic wave as it recedes from the seismic center, but the area of damage is clearly marked.

(4) The cause of the earthquake whatever it may be, whether it be a fissure, or the formation of a volcanic rent, or a subterranean falling in, or explosion, or what not, is comparatively near the surface.

(5) There are no evident volcanic phenomena accompanying the earthquake.

(6) If the seismic wave is felt outside of the island at all it is felt very slightly.

(7) There is no disturbance of the sea.

(8) Three days after the earthquake of 1881 there was not the least vibration of the soil discernible even with a microphone. Strange to say no notice one way or the other has reached me with regard to the earthquake of 1883.

Conclusions.—(1) That it is very much to be regretted that after the disaster of 1881 no efficient measures were taken to investigate the physical phenomena of the island of Ischia.

(2) That it is very difficult to arrive at any positive conclusion from reading the different reports. On doing so, one has an intimate feeling that every one goes there with a pre-conceived theory and only hunts out facts to corroborate it.

(3) The fact of the earthquake not having been sensibly felt in Naples or on the adjoining shore should not influence our judgment much either way, for in 1857 Capri scarcely felt the shock which was very severe in the promontory of Sorrento. Now the promontory and the island belong to the same geological formation and are very near each other.

On the other hand the motion noticed by Professor Rossi in his instruments at Rome, and the various phenomena he mentions in connection with the Ischian earthquake, as happening at that time near Rome, are not by any means necessarily connected with the Ischian earthquake.

Although in all Ischian earthquakes some commotion on the continent has been noticed, this commotion has invariably taken place at a very considerable distance, while in the immediate neighborhood no motion was perceptible. It is very problematical whether these distant motions are anything but a coincidence.

(4) When one thinks of the enormous amount of lava which has been ejected from the many cones on the island one can understand that there may be enormous cavities below the soil.

When we consider the corroding influence of carbonic acid and water: and the great number of hot springs and the quantity of water they are continually pouring forth and have been pouring forth since time immemorial, that cavities may exist becomes still more evident.

If besides this, we remember that sufficient clay is being continually taken out of the soil to furnish bricks, tiles and cooking utensils not only for the island itself but for all the neighboring mainland; that this clay is not on the surface but is all taken from excavations and galleries, mined as it were; that this process is by no means a new one but has been going on for generations; we see then causes tending still further to honeycomb the soil. The soil therefore being cavernous, a sudden collapse is not only possible but probable, and we can understand that it might produce remarkable effects.

(5) The great suddenness and localization of the Ischian earthquake, together with the absence of any volcanic phenomena, should induce us to seek some other cause for the earthquake than a volcanic one; and as we have a set of conditions in the nature of the ground itself amply sufficient to account for most of the phenomena, we are justified, in the absence of further evidence, in considering this as an efficient cause. Whether the accidental cause was a fissure, a seismic wave, or an explosion or what not, is a consideration which only a lengthened and methodical observation in the future will enable us to find out.

3. *The Azoic System and its proposed Subdivisions;* by J. D. WHITNEY and M. E. WADSWORTH. pp. 331–566, of vol. vii of Bulletin of the Mus. Comp. Zool. Cambridge, August, 1884.—The Azoic system—or Archæan, as it is now commonly called—was early made the subject of investigations by Professor J. D. Whitney and now finds in him a valuable exponent. The litera-

ture of the "Azoic" and the opinions of the various investigators in "Azoic" regions or writers on "azoic" questions are here reviewed by the authors, by means of a free use of citations and full explanations, accompanied and followed by critical remarks. The criticisms are largely just, though often expressed with a positiveness not altogether consistent with the uncertainties about such questions. Of course, as with other writers, they are in part determined by the special opinions of the authors, and are reasonable subjects for counter-discussion. The work is a valuable addition to the history of American geological science; and will be increasingly valued as the discussion of the subject proceeds.

Among the conclusions set forth, that as to the *azoic* condition of the "Azoic" era seems to be quite too doubtful to be accepted without a question. It is true that the supposed evidences of life in the late Archæan stratified rocks are doubtful; that the Eozoon is still among problematical things; that the limestones of the Archæan contain no fossils, so far as is positively known; but at the same time it is true that the "Azoic" is not yet proved to have been azoic,—is not yet proved to have *probably* been azoic; it is also true that the Archæan limestones have not been proved to be of chemical origin, or to be not of organic origin. The evidences on both sides are still doubtful evidences; and being so, it is impossible for most minds to settle down into the positive belief that the era was to the end without life or that the existence of life then was improbable; and hence the adoption of the non-committal term *Archæan* for the rocks and events of time preceding the Primordial—agreeing in limits as far as its proposer, the writer, understands (notwithstanding some remarks in the volume) with Whitney's Azoic.

The subdivisions of the Archæan are considered in the volume at much length and shown to be—even that of the Huronian—without a satisfactory basis. J. D. D.

4. *Thirteenth annual report on the Geology and Natural History of Indiana;* by JOHN COLLETT, State Geologist. 161 and 264 pp. 8vo, with many plates and a geological map. Indianapolis, 1884.—Besides a general review of the geology of the State and chapters on the local geology of some of its counties, this report contains tabular results of experiments on the heating value of Indiana coals, and about 180 pages on a review of its paleontology—including both vegetable and animal species. This paleontological part of the report is illustrated by 39 plates, more than half of which are plates of fossil plants. The botanical portion is by the able author on the subject, Leo Lesquereux, and includes an introduction on the formation of coal and other points of general interest. Mr. Lesquereux derives from the number of species of coal plants found in the nodules of the shale at Mazon Creek, Illinois and from the same shale elsewhere, that at least 200 species of plants contributed to the formation of a single bed of coal; and adding other species from the same horizon, the number

becomes 250. The review of the fossil invertebrates is by the well-known paleontologist Dr. C. A. White.

Mr. Collett has increased much the value of the volume by the insertion of a colored geological map of the State, compiled from the labors of the former State Geologist, Mr. Cox, and those of other workers in Indiana geology.

5. *Fossils as a criterion of Geological equivalency.*—The uncertainties connected with the use of fossils as a criterion of geological age was the subject of the able address before the geological section of the British Association at Montreal by its president, Mr. W. T. Blanford, formerly deputy superintendent of the Geological Survey of India. After reviewing the facts, and pointing out the diversity of opinions as to age, connected with the Tertiary Mammalian deposits of Pikermi, Greece, of Siwalik in the northwestern Himalaya, and of Sind; those pertaining to the fossils, chiefly plants, of the Gondwâna system of India, and those of the coal-measures of Australia and the Karoo beds of South Africa, Mr. Blanford states objections to the commonly received view with regard to the approximate universality of faunas, floras and climates in ancient time, and concludes with the following recapitulation.

(1) That the geological age assigned on homotaxial grounds to the Pikermi and Siwalik mammalian faunas is inconsistent with the evidence afforded by the associated marine deposits.

(2) The age similarly assigned on the same data to the different series of the Gondwâna system of India is a mass of contradictions; beds with a Triassic fauna overlying others with Rhætic or Jurassic floras.

(3) The geological position assigned on similar evidence to certain Australian beds is equally contradictory, a Jurassic flora being of the same age as a Carboniferous marine fauna.

(4) The same is probably the case with the terrestrial and fresh-water faunas and floras of South Africa.

(5) In instances of conflicting evidence between terrestrial or fresh-water faunas and floras on one side, and marine faunas on the other, the geological age indicated by the latter is probably correct, because the contradictions which prevail between the evidence afforded by successive terrestrial and fresh-water beds are unknown in marine deposits; because the succession of terrestrial animals and plants in time has been different from the succession of marine life; and because in all past times the differences between the faunas and floras of distant lands have probably been, as they now are, vastly greater than the differences between the animals and plants inhabiting the different seas and oceans.

(6) The geological age attributed to fossil terrestrial faunas and floras in distant countries on account of the relations of such faunas and floras to those found in European beds has proved erroneous in so large a number of cases that no similar determinations should be accepted unless accompanied by evidence from marine beds. It is probable in many cases—perhaps in the

majority—where the age of beds has been determined solely by the comparison of land or fresh-water animals or plants with those found in distant parts of the globe, that such determinations are incorrect.

6. *The Geology of Minnesota*, vol. I of the Final Report; by N. H. WINCHELL, assisted by WARREN UPHAM. 698 pp. 4to, with 43 plates.—This large and handsome volume commences with an excellent historical sketch of explorations in Northwestern America, from early in the 17th century to the present time, which is illustrated by reproductions of several old maps of North America (or of parts including Minnesota)—those by Hennepin (1683), Franquelin (1688), De L'Isle (1703), De Beauharnois (1737), Buache (1754); and that of Nicollet, of 1842, the result of an important topographical survey. The physical features of Minnesota are next described by Professor Winchell; the building stones, by the same; and then follow chapters on the geology of twenty-eight counties by Mr. Winchell and Mr. Upham, excepting that two of them are by Mr. M. W. Harrington. Of the 84,286 of square miles in the State, the lakes make up 5,637 square miles; and nearly all the rest is under drift—the "only exceptions being the extreme southeastern and the extreme northeastern portions" and some scattered outcrops elsewhere; and this drift in the southern half of the State is an almost unbroken mantle from 100 to 200 and sometimes 300 feet thick. The geology of the State hence is relatively simple. The chapter on building stones is the result of a careful study of the rocks, which included trials of strength besides ordinary and chemical analyses, the former by Professor J. A. Dodge, the latter by the same and his assistant Mr. C. F. Sidener. Four syenytes: 1. from Sherburne Co., 2. Beaver Bay Lake Co., 3, 4. Watab, Benton Co., afforded:

	SiO_2	AlO_3	FeO_3	MgO	CaO	K_2O	Na_2O
1. Gray syenyte...	65·12	16·96	4·69	1·99	4·77	2·18	3·07 = 98·78
2. Red syenyte....	71·81	12·82	6·02	0·56	2·26	2·51	1·92 = 97·90
3. Whitish syenyte	62·06	19·29	4·67	3·06	5·93	1·62	2·45 = 99·68
4. Red syenyte....	78·12	11·14	2·68	*tr.*	0·62	4·48	3·33 = 100·97

The chapters on the geology of the counties are illustrated by detailed maps. The noted locality of red pipestone of the "northwestern territory" is in Pipestone County, and a full history and description of it are given by Professor Winchell. The pipestone is a bed of indurated clay in the red quartzyte of the region.

7. *Tertiary Geology of the Eastern and Southern United States.*—Professor A. Heilprin's paper on this subject, noticed in volume xxiv of this Journal (1882), on page 228, is published in full in the Journal of the Academy of Natural Sciences of Philadelphia, Part I of vol. ix (1884).

8. *On the Development and Generic relations of the Corals of the Carboniferous System of Scotland;* by Mr. JAMES THOMSON, F.G.S. 208 pp. 8vo, with 14 plates. Read before the Philosophical Society of Glasgow, March 14th, 1883.—This memoir bears

evidence of being the result of much investigation. It discusses the relations of the various genera of Carboniferous corals and gives descriptions of many new species. A large number of species are figured on the plates, and many of the figures are from thin sections of the corals, illustrating growth and bud-development as well as distinctions in structure.

9. *Geologie von Bayern* (Bavaria), von Dr. K. W. VON GUMBEL. 1st part: Elements of Geology, and 1st "Lieferung," 208 pp., with numerous illustrations in the text. Kassel, 1884 (Theodor Fischer).—This volume is the first portion of an extended work on geology by Dr. von Gümbel, and includes an account of the constituents of rocks, and the methods of investigating them, descriptions of the constituent minerals, and then of the rocks themselves through part of the series. The cuts are illustrations of the optical characters of the minerals and rocks; and a large part of the rocks described are thus illustrated. The work promises to be an important contribution to geological science as well as a valuable text-book.

10. *Microscopic organisms in the Bowlder Clays of Chicago and vicinity;* by Messrs. Dr. H. A. JOHNSON and B. W. THOMAS. (Bull. Chicago Acad. Sci., 1884.)—The authors of this paper report that the clay taken out from beneath Lake Michigan, in making the tunnel in 1865 to 1867 for supplying the city of Chicago with water, was found at that time to contain yellowish microscopic discs 1-85th to 1-250th of an inch in diameter. The facts were the occasion of the recent appointment of a committee by the Academy to make a general examination of the bowlder clays about Chicago; and the discoveries made by this committee are the subject of the recent communication. The clays contain fragments of shale, and from both the clay and the shale these discs were obtained. They are regarded as the macrospores of acrogenous plants, and similar to the *Sporangites bilobatus* or *Sp. Huronensis* of Dawson from Devonian shales. Along with the discs are "broken pieces of what seem to have been leaves." The clay underneath Chicago and its vicinity is full of bowlders, of various sizes up to several cubic yards, many with "ice-markings;" and some of the smaller are a carbonaceous shale which is apparently identical with that of the Upper Devonian; like that it burns with a bright clear flame giving out a strong petroleum odor.

Mr. Thomas, in a note appended to the article, states that he has detected the macrospores in the clay and in its imbedded fragments of shale along the west shore of Michigan from Kenosha, Wisconsin, to the Indiana line. In a "blue bowlder clay," from Litchfield, in Central Minnesota, he found an abundance of several species of fossil Rhizopods, fragments of Diatoms, and among the foraminifers, *Textilaria globosa*, *Rotalia globosa* and *Globigerina* (as identified by Dr. Joseph Leidy). The forms are marine and are supposed to come from Cretaceous beds. In a clay of the lower drift, from Bloomington, Illinois, at a depth of 135 feet below the surface, occurs a stratum of black soil containing quantities of well preserved timber, with stumps of trees apparently in their natural position, and affording also discs like the macrospores of the Chicago clays, except that they are smaller.

11. *International Geological Congress.*—The meeting of the International Congress at Berlin has been deferred a year, in consequence of the cholera in Europe.

12. *Text-book of Descriptive Mineralogy;* by HILARY BAUERMANN, F.G.S. 399 pp. 12mo. London, 1884 (Longmans, Green & Co.).—This volume is a companion to the *Treatise on Systematic Mineralogy* by the same author, published some three years since (this Journal, xxi, 506). The descriptions of species are brief, from the necessity of the case, but the matter is well selected and well arranged, so that the ordinary student will readily find almost all the information he needs. The work has many excellent features, not the least so being the figures printed from the original blocks used by Brooke and Miller, thirty years ago. It is not as fully up to date as it might be; thus we are told of cyanite that the "dimensions are undetermined;" no mention is made of vanadinite from Arizona, of danburite from Switzerland; and indeed it might be criticised in other minor points.

13. *On Herderite.*—Dr. A. WEISBACH has recently published a note in the Jahrbuch für Mineralogie (ii, 134, 1884) in which he gives the results of analyses by Winkler of the original herderite from Ehrenfriedersdorf and also of the allied mineral from Stoneham, Maine, first described by W. E. Hidden (this Journal, xxvii, 73, 135, 229). These analyses are quoted here, with also that made by J. B. Mackintosh upon the Stoneham mineral.

	1. Ehrenfriedersdorf. Winkler.	2. Stoneham. Winkler.	3. Stoneham. Mackintosh.
Phosphorus pentoxide	42·44	41·51	44·31
Beryllium oxide	8·61	14·84	15·76
Alumina	6·58	2·26	....
Iron sesquioxide	1·77	1·18	....
Lime	34·06	33·67	33·21
Water	[6·54]	6·59	loss 6·72
	100·00	100·05	100·00
			Fl 11·32

Analyses 1 and 2 were made upon 39·5^{mm} and 101·7^{mm} respectively. A comparison between analyses 2 and 3 shows that according to Winkler the Stoneham mineral contains some aluminum and iron together with the beryllium, and also that it contains water instead of fluorine—Winkler remarks upon a doubtful fluorine reaction, but is inclined to regard the loss as water. This loss, determined directly, he found to be 3·54 per cent at 350° and 7·59 at a red heat. Further it is seen that the original herderite differs from the Stoneham mineral in containing about half the beryllium replaced by aluminum and iron. The formula calculated from Winkler's results, if only beryllium is assumed

be present, is $Ca_6Be_4P_6O_{27}+4H_2O$, which requires: phosphorus
ntoxide 43·23, beryllium oxide 15·34, lime 34·13, water 7·30=100.
viously, however, the material employed was too scanty to
ke the results thoroughly satisfactory. It is much to be
sired that a new analysis of the Stoneham mineral may be
de upon an amount of material sufficient to ensure accuracy,
d thus its true composition be once for all established.
d collectors of antiquities. R.

14. *Deep-sea Fauna.*—In his address before the Biological
ction of the British Association at Montreal, H. N. MOSELEY,
q., President of that Section, and one of the Naturalists of the
allenger Expedition, states as a striking characteristic of the
ep-sea fauna, the absence of Paleozoic types except among repre-
tatives of Mollusks and Brachiopods; of representatives of the
utilidæ and Ammonitidæ; and of Lingulæ, these being, so far
has been discovered, shallow-water species. Mr. Moseley con-
des that with little doubt the deep-sea fauna has been derived
m the littoral and pelagic faunas. The fact that the young of
toral species are largely free-swimming and pelagic, and that
lagic species are often larval in form, favors the idea of their
ing ancestral; and he infers, thence, that by later modifications,
pelagic forms became adapted to the rougher littoral condi-
ns; and from the littoral distribution later came the deep-sea
.

15. *Linnæan Society of New York*, vol. II.—This second vol-
e of the N. Y. Linnæan Society contains two papers by Dr. C.
Merriam, on the Vertebrates of the Adirondack Region (con-
ding the Mammalia), and a description of a new genus and
ecies of the Sorecidæ, *Atophyrax Bendirii.* The latter is illus-
ted by a plate. The shrew was obtained by Captain Bendire
out 18 miles southeast of Fort Klamath and a mile from Wil-
mson's River. It is one of the largest of the Shrews.

16. GEORGE BENTHAM, *facile princeps* of Systematic Botanists
our day, died on the 10th of September, at his residence in
ndon, at the ripe age of 84. An account of his life and
entific work may be expected in a future number of this
urnal. A. G.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Annals of the Astronomical Observatory of Harvard Col-
e*, vol. xiv, Pt. 1, 324 pp. *Observations with the Meridian
otometer during the years* 1879–82; by EDWARD C. PICKER-
, Director, aided by ARTHUR SEARLE and OLIVER C. WEN-
LL, Assistants in the Observatory. Cambridge, 1884.—This
lume contains the results of photometric observations carried
at the Harvard Observatory between October 25, 1879 and
ptember 17, 1882. The number of stars included is 4,260 being
those estimated to be of the first six magnitudes. The obser-
tions comprised 700 series and included 94,476 separate com-

parisons, or, including preliminary observations and those on stars not conprised in the catalogue, the total number exceeds one hundred thousand. These numbers are quoted as showing the magnitude of the work which has thus been successfully accomplished. The successive chapters in Part I, now published, contain a description of the photometer, a summary of series, a discussion of the effect of atmospheric absorption, results of direct eye estimates of relative brightness of the stars, the general catalogue, and some miscellaneous points connected with the work. The volume is accompanied by three plates.

2. *Dimensions of the Gulf of Mexico.* (Communication to Mr. J. E. Hilgard, Superintendent of the U. S. Coast and Geodetic Survey, by A. LINDENKOHL, Assistant in the Coast Survey.— According to the calculation given in your "Basin of the Gulf of Mexico" (see this Journal, vol. xxi, April, 1881), the area of the Gulf of Mexico is 595,000 square miles and the area of the surface included within the 100-fathom line, 387,000 square miles; hence rather more than one-third of the surface of the Gulf (35 per cent) has a depth below 100 fathoms. The mean depth of the Gulf is 858 fathoms, which means that a basin of the same surface with the Gulf, and of the uniform depth of 858 fathoms will have the same capacity as the Gulf. Cutting off the banks, or those parts of the Gulf which are less than 100 fathoms deep, we obtain 1276 fathoms for the mean depth of the remainder. The figures 858 and 1276 are almost exactly in the ratio of two to three. The greatest recorded depth in the Gulf is 2119 fathoms, hence it will be seen that the mean depth is ⅖ of the greatest and the mean depth of the deeper parts ⅗ of the same.

3. *Bureau of Scientific Information. A generous gift of time and knowledge by members of the Academy of Natural Sciences of Philadelphia.*—With a view toward the more general dissemination of the results of scientific investigation, and of facilitating the work of the student in natural history, the following members and officers of the Academy of Natural Sciences have associated themselves into a Bureau of Scientific Information, whose function is to be the imparting, through correspondence, of precise and definite information bearing upon the different branches of the natural sciences. It is believed that through an organization of this kind considerable assistance can be rendered to those who, by the nature of their environs, are precluded from the advantages to be derived from museums and libraries.

The organization is of a purely voluntary character, and it is to be hoped that no unnecessary burden will be imposed upon its members by communications of an essentially trivial nature. The scope of the organization does not embrace considerations of a purely professional character—such as mineral or chemical analyses—nor the determination of collections, except by special agreement. The respondents may be addressed directly, care of the Bureau of Scientific Information, Academy of Natural Sciences. A return stamp (two cents) is all that is asked.

The bureau consists of the following persons: Joseph Leidy, M.D., Mycetozoa, Rhizopoda, Entozoa, Vertebrate Paleontology; Edward Potts, Pond Life, Fresh-water Sponges and Bryozoa; George W. Tryon, Jr., Conchology; Benjamin Sharp, M.D., Worms, Annelids, Histology; G. H. Horn, M.D., North American Coleoptera; H. C. McCook, D.D., Ants, Spiders, Insect Architecture; Henry Skinner, M.D., North American Moths; Eugene M. Aaron, Diurnal Lepidoptera; W. N. Lockington, Echinoderms, Fishes; Spencer Trotter, M.D., North American Ornithology; Thomas Meehan, Exotic and Cultivated Plants; J. H. Redfield, Ferns and North American Phanerogamic Plants; J. T. Rothrock, Vegetable Physiology; F. Lamson Scribner, Grasses; H. Carvill Lewis, Mineralogy, Glacial and Stratigraphical Geology; Angelo Heilprin, Invertebrate Paleontology, Physiography, Dynamical Geology; D. G. Brinton, M.D., Ethnology, American Linguistics and Archæology; Harrison Allen, M.D., Teratology; J. Gibbons Hunt, M.D., Microscopical Technology; E. J. Nolan, M.D., Bibliography of Natural History. Chairman, Professor Harrison Allen; Secretary, Professor Angelo Heilprin.

4. *Report upon the unification of Longitudes and a Universal time;* by BENJAMIN A. GOULD. Buenos Aires, July, 1884.—This report to the Minister of Public Instruction at Buenos Aires contains a brief discussion of the resolutions of the International Geodetic Conference, passed at their triennial session in Rome in October last. After stating his objections to the proposed method of numbering longitudes from west to east and the reason why the reversed order is to be preferred, Dr. Gould goes on to speak of the adoption of an international time.

"It is my belief that an accordance of all governments can be obtained in this matter of international time, with the same unanimity as in that of a common prime meridian, and I anticipate little difference of opinion upon the subject in the Washington Convention. The only probable discordance is relative to details in its application.

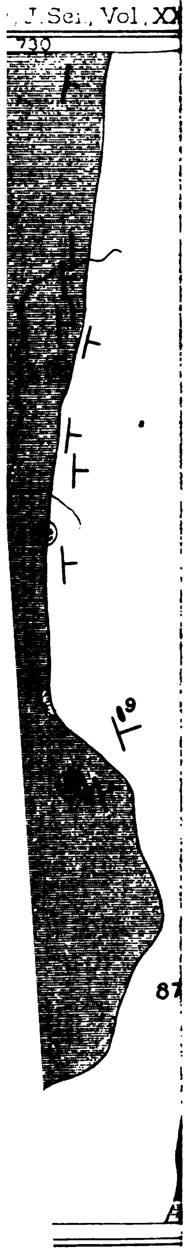
"An obstacle has nevertheless unexpectedly arisen in the United States, within the last few months, by the introduction, in many places, of a new system which I cannot but consider ill-judged and even mischievous; although it was designed to obviate the same difficulties which have prompted the suggestion of a universal time. The endeavor has been made, with considerable temporary success, to force into general use, in the interest of the railway companies, a system of time which is neither universal, local, nor scientific. Dividing the continent into sections by the meridians midway between those of 4^h, 5^h, 6^h, 7^h, and 8^h from Greenwich, it is attempted to introduce, throughout each of these sections, one and the same system of time for use both by the railroads and by citizens in their daily life. The time employed is that of Greenwich for the minutes and seconds, but using that hour which is nearest to the local mean time. . . . . The accordance of the public clocks, thus obtained for the various cities in the same section, is a matter of some convenience for travelers and great advantage for the railroads; but it is secured by sacrifices which not only outweigh these advantages, but are in fact quite needless, since the desired end can be better attained by the total abandonment of any attempt to force an erroneous standard of time upon the community, and the adoption of the recommendation of the Geodetic conference.

"The facts of Nature demand a certain recognition; and the absurdity of the attempted change differs in degree only, not in kind, from that of a division of the year into a given number of equal lunations, or the month into a round number of equal days. The large deviation from the truth, in the standard of time thus imposed upon the inhabitants of regions near the boundaries of the proposed sections, can sometimes amount to three-quarters of an hour; and the moment to which the name of noon is thus given would divide the day into two unequal parts, whose inequality would, at certain seasons of the year, be very little less than an hour and a half. A man visiting his next door neighbor might find his watch to be an hour wrong. Such incongruities embarrass the affairs of daily life.

"Only some very strong necessity could justify such inconveniences and violations of natural laws; and no necessity exists. The only proper solution of the difficulty is by the establishment and maintenance of a distinct system of time, through the employment of a separate meridian for purposes other than local. This is now done by all navigators, all telegraph companies, and all railways of magnitude; and the reform now proposed by the International Geodetic Conference is simply that this separate meridian shall be the same for all, and in every part of the globe, and be likewise available for scientific purposes. The inconvenience of maintaining simultaneously two systems of time is reduced to a minimum when they are so different as to preclude all danger of confusion, when they are so easily convertible, and when one of them is identical for all the world. The method now proposed for attaining this end fulfils all these conditions; it entails less sacrifices than those required for the so-called 'standard time' of the North American railroads; and it cannot fail to afford practical, commercial and scientific advantages, while adding one more to the various bonds which are, of late years, uniting the nations of the earth in closer relations."

5. *The National Dispensatory*, containing the Natural History, Chemistry, Pharmacy, Actions and Uses of Medicines; by A. STILLÉ, M.D., LL.D. and J. M. MAISCH, Pharm.D. 1,756 pp. Philadelphia, 1884 (H. C. Lea's Son & Co.).—A third edition of this standard work has been just issued, in which it has been thoroughly revised and much enlarged. The very large volume is handsomely printed and has many illustrations.

A final Report on the Crustacea of Minnesota, included in the orders Cladocera and Copepoda, together with a synopsis of the described species in North America and keys to the known species of the more important genera, by L. C. Herrick. 192 pp. 8vo, illustrated by 22 plates. From the 12th Ann. Rep. Geol. and Nat. Survey of Minnesota, Minneapolis, 1884.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[THIRD SERIES.]

T. XXXIX.—*Characteristics of the North American Flora: n Address to the Botanists of the British Association for the dvancement of Science at Montreal; read to the Biological ection, August* 29; by ASA GRAY.

VHEN the British Association, with much painstaking, iors and gratifies the cultivators of science on this side of ocean by meeting on American soil, it is but seemly that a responding member for the third of a century should en- vor to manifest his interest in the occasion and to render ie service, if he can, to his fellow-naturalists in Section D. vould attempt to do so by pointing out, in a general way, ie of the characteristic features of the vegetation of the intry which they have come to visit,—a country of "mag- cent distances," but of which some vistas may be had by se who can use the facilities which are offered for enjoying m. Even to those who cannot command the time for dis- t excursions, and to some who may know little or nothing botany, the sketch which I offer may not be altogether un- eresting. But I naturally address myself to the botanists of Association, to those who, having crossed the wide Atlantic, now invited to proceed westward over an almost equal adth of land; some, indeed, have already journeyed to the cific coast, and have returned; and not a few, it is hoped, y accept the invitation to Philadelphia, where a warm wel- ne awaits them—warmth of hospitality, rather than of sum- r temperature, let us hope; but Philadelphia is proverbial for both. There opportunities may be afforded for a passing acquaintance with the botany of the Atlantic border of the United States, in company with the botanists of the American Association, who are expected to muster in full force.

What may be asked of me, then, is to portray certain outlines of the vegetation of the United States and the Canadian Dominion, as contrasted with that of Europe; perhaps also to touch upon the causes or anterior conditions to which much of the actual differences between the two floras may be ascribed. For, indeed, however interesting or curious the facts of the case may be in themselves, they become far more instructive when we attain to some clear conception of the dependent relation of the present vegetation to a preceding state of things, out of which it has come.

As to the Atlantic border on which we stand, probably the first impression made upon the botanist or other observer coming from Great Britain to New England or Canadian shores, will be the similarity of what he here finds with what he left behind. Among the trees the White Birch and the Chestnut will be identified, if not as exactly the same, yet with only slight differences—differences which may be said to be no more essential or profound than those in accent and intonation between the British speech and that of the "Americans." The differences between the Beeches and Larches of the two countries are a little more accentuated; and still more those of the Hornbeams, Elms, and the nearest resembling Oaks. And so of several other trees. Only as you proceed westward and southward will the differences overpower the similarities, which still are met with.

In the fields and along open roadsides the likeness seems to be greater. But much of this likeness is the unconscious work of man, rather than of Nature, the reason of which is not far to seek. This was a region of forest, upon which the aborigines, although they here and there opened patches of land for cultivation, had made no permanent encroachment. Not very much of the herbaceous or other low undergrowth of this forest could bear exposure to the fervid summer's sun; and the change was too abrupt for adaptive modification. The plains and prairies of the great Mississippi Valley were then too remote for their vegetation to compete for the vacancy which was made here when forest was changed to grain-fields and then to meadow and pasture. And so the vacancy came to be filled in a notable measure by agrestial plants from Europe, the seeds of which came in seed-grain, in the coats and fleece and in the imported fodder of cattle and sheep, and in the various but not always apparent ways in which agricultural and commercial people unwittingly convey the plants and animals of one country to another. So, while an agricultural people displaced the aborigines which the forest sheltered and nourished, the herbs, purposely or accidentally brought with them, took possession of the clearings, and prevailed more or less over the native and rightful heirs to the soil,—not enough to supplant them, indeed, but enough to impart a certain adventitious Old World aspect to the fields and other open grounds, as well as to the precincts of habitations. In springtime you would have seen the fields of this district yellow with European Buttercups and Dandelions, then whitened with the Ox-eye Daisy, and at midsummer brightened by the cærulean blue of Chiccory. I can hardly name any native herbs which *in the fields and at the season* can vie with these intruders in floral show. The common Barberry of the Old World is an early denizen of New England. The tall Mullein, of a wholly alien race, shoots up in every pasture and new clearing, accompanied by the common Thistle, while another imported Thistle, called in the States "the Canada Thistle," has become a veritable nuisance, at which much legislation has been leveled in vain.

According to tradition the wayside Plantain was called by the American Indian "White-Man's foot," from its springing up wherever that foot had been planted. But there is some reason for suspecting that the Indian's ancestors brought it to this continent. Moreover there is another reason for surmising that this long-accepted tradition is factitious. For there was already in the country a native Plantain, so like *Plantago major* that the botanists have only of late distinguished it. (I acknowledge my share in the oversight.) Possibly, although the botanists were at fault, the aborigines may have known the difference. The cows are said to know it. For a brother botanist of long experience tells me that, where the two grow together, cows freely feed upon the undoubtedly native species, and leave the naturalized one untouched.

It has been maintained that the ruderal and agrestial Old World plants and weeds of cultivation displace the indigenous ones of newly-settled countries in virtue of a strength which they have developed through survival in the struggle of ages, under the severe competition incident to their former migrations. And it does seem that most of the pertinacious weeds of the Old World which have been given to us may not be indigenous even to Europe, at least to Western Europe, but belong to campestrine or unwooded regions farther east; and that, following the movements of pastoral and agricultural people, they may have played somewhat the same part in the once forest-clad Western Europe that they have been playing here. But it is unnecessary to build much upon the possibly fallacious idea of increased strength gained by competition. Opportunity may count for more than exceptional vigor; and the cases in which foreign plants have shown such superiority are mainly those in which a forest-destroying people have brought upon newly-bared soil the seeds of an open-ground vegetation.

The one marked exception that I know of, the case of recent and abundant influx of this class of Old-World plants into a naturally treeless region, supports the same conclusion. Our associate, Mr. John Ball, has recently called attention to it. The pampas of Southeastern South America beyond the Rio Colorado, lying between the same parallels of latitude in the South as Montreal and Philadelphia in the North, and with climate and probably soils fit to sustain a varied vegetation, and even a fair proportion of forest, are not only treeless, but excessively poor in their herbaceous flora. The district has had no trees since its comparatively recent elevation from the sea. As Mr. Darwin long ago intimated: "Trees are absent not because they cannot grow and thrive, but because the only country from which they could have been derived—tropical and sub-tropical South America—could not supply species to suit the soil and climate." And as to the herbaceous and frutescent species, to continue the extract from Mr. Ball's instructive paper recently published in the Linnean Society's Journal, "in a district raised from the sea during the latest geological period, and bounded on the west by a great mountain range mainly clothed with an alpine flora requiring the protection of snow in winter, and on the north by a warm-temperate region whose flora is mainly of modified sub-tropical origin—the only plants that could occupy the newly-formed region were the comparatively few which, though developed under very different conditions, were sufficiently tolerant of change to adapt themselves to the new environment. The flora is poor, not because the land cannot support a richer one, but because the only regions from which a large population could be derived are inhabited by races unfit for emigration."

Singularly enough, this deficiency of herbaceous plants is being supplied from Europe, and the incomers are spreading with great rapidity; for lack of other forest material even apple-trees are running wild and forming extensive groves. Men and cattle are, as usual, the agents of dissemination. But colonizing plants are filling, in this instance, a vacancy which was left by nature, while ours was made by man. We may agree with Mr. Ball in the opinion that the rapidity with which the intrusive plants have spread in this part of South America "is to be accounted for, less by any special fitness of the immigrant species, than by the fact that the ground is to a great extent unoccupied."

The principle applies here also; and in general, that it is opportunity rather than specially acquired vigor that has given Old-World weeds an advantage may be inferred from the behavior of our weeds indigenous to the country, the plants of the unwooded districts—prairies or savannas west and south,—which, now that the way is open, are coming in one by one into these eastern parts, extending their area continually, and holding their ground quite as pertinaciously as the immigrant denizens. Almost every year gives new examples of the immigration of campestrine western plants into the Eastern States. They are well up to the spirit of the age; they travel by rail-way. The seeds are transported, some in the coats of cattle and sheep on the way to market, others in the food which supports them on the journey, and many in a way which you might not suspect, until you consider that these great roads run east and west, that the prevalent winds are from the west, that a freight-train left unguarded was not long ago blown on for more than one hundred miles before it could be stopped, not altogether on down grades, and that the bared and mostly unkempt borders of these railways form capital seed-beds and nursery grounds for such plants.

Returning now from this side-issue, let me advert to another and, I judge, a very pleasant experience which the botanist and the cultivator may have on first visiting the American shores. At almost every step he comes upon old acquaintances, upon shrubs and trees and flowering herbs, mostly peculiar to this country, but with which he is familiar in the grounds and gardens of his home. Great Britain is especially hospitable to American trees and shrubs. There those both of the eastern and western sides of our continent flourish side by side. Here they almost wholly refuse such association. But the most familiar and longest-established representatives of our flora (certain western annuals excepted) were drawn from the Atlantic coast. Among them are the Virginia Creeper or Ampelopsis, almost as commonly grown in Europe as here, and which, I think, displays its autumnal crimson as brightly there as along the borders of its native woods where you will everywhere meet with it; the Red and Sugar Maples, which give the notable autumnal glow to our northern woods, but rarely make much show in Europe, perhaps for lack of sharp contrast between summer and autumn; the ornamental Ericaceous shrubs, Kalmias, Azaleas, Rhododendrons, and the like, specially called American plants in England, although all the Rhododendrons of the finer sort are half Asiatic, the hardy American species having been crossed and recrossed with more elegant but tender Indian species.

As to flowering herbs, somewhat of the delight with which an American first gathers wild Primroses and Cowslips and Foxgloves and Daisies in Europe, may be enjoyed by the European botanist when he comes upon our Trilliums and Sanguinaria, Cypripediums and Dodecatheon, our species of Phlox, Coreopsis, etc., so familiar in his gardens; or, when, crossing the continent, he comes upon large tracts of ground yellow with Eschscholtzia or blue with Nemophilas. But with a sentimental difference; in that Primroses, Daisies, and Heaths, like nightingales and larks, are inwrought into our common literature and poetry, whereas our native flowers and birds, if not altogether unsung, have attained at the most to only local celebrity.

Turning now from similarities, and from that which interchange has made familiar, to that which is different or peculiar, I suppose that an observant botanist upon a survey of the Atlantic border of North America (which naturally first and mainly attracts our attention) would be impressed by the comparative wealth of this flora in trees and shrubs. Not so much so in the Canadian Dominion, at least in its eastern part; but even here the difference will be striking enough on comparing Canada with Great Britain.

The Coniferæ, native to the British Islands, are one Pine, one Juniper, and a Yew; those of Canada proper are four or five Pines, four Firs, a Larch, an Arbor-Vitæ, three Junipers, and a Yew,—fourteen or fifteen to three. Of Amentaceous trees and shrubs, Great Britain counts one Oak (in two marked forms), a Beech, a Hazel, a Hornbeam, two Birches, an Alder, a Myrica, eighteen Willows, and two Poplars,—twenty-eight species in nine genera, and under four natural orders. In Canada there are at least eight Oaks, a Chestnut, a Beech, two Hazels, two Hornbeams of distinct genera, six Birches, two Alders, about fourteen Willows and five Poplars, also a Plane tree, two Walnuts and four Hickories; say forty-eight species, in thirteen genera, and belonging to seven natural orders. The comparison may not be altogether fair; for the British flora is exceptionally poor, even for islands so situated. But if we extend it to Scandinavia, so as to have a continental and an equivalent area, the native Coniferæ would be augmented only by one Fir, the Amentaceæ by several more Willows, a Poplar, and one or two more Birches;—no additional orders nor genera.

If we take in the Atlantic United States, east of the Mississippi, and compare this area with Europe, we should find the species and the types increasing as we proceed southward, but about the same numerical proportion would hold.

But, more interesting than this numerical preponderance—which is practically confined to the trees and shrubs—will be the extra-European types, which, intermixed with familiar old-world forms, give peculiar features to the North American flora,—features discernible in Canada, but more and more prominent as we proceed southward. Still confining our survey to the Atlantic district, that is, without crossing the Mississippi, the following are among the notable points:

1. Leguminous Trees of peculiar types. Europe abounds in leguminous shrubs or under-shrubs, mostly of the Genisteous tribe, which is wanting in all North America, but has no leguminous tree of more pretense than the Cercis and Laburnum. Our Atlantic forest is distinguished by a Cercis of its own, three species of Locust, two of them fine trees, and two Honey Locusts, the beautiful Cladrastis, and the stately Gymnocladus. Only the Cercis has any European relationship. For relatives of the others we must look to the Chino-Japanese region.

2. The great development of the Ericaceæ (taking the order in its widest sense), along with the absence of the Ericeous tribe, that is, of the Heaths themselves. We possess on this side of the Mississippi 30 genera and not far from 90 species. All Europe has only 17 genera and barely 50 species. We have most of the actual European species, excepting their Rhododendrons and their Heaths,—and even the latter are represented by some scattered patches of Calluna, of which it may be still doubtful whether they are chance introductions or sparse and scanty survivals; and besides we have a wealth of peculiar genera and species. Among them the most notable in an ornamental point of view are the Rhododendrons, Azaleas, Kalmias, Andromedas and Clethras; in botanical interest, the endemic Monotropeæ, of which there is only one species in Europe, but seven genera in North America, all but one absolutely peculiar; and in edible as well as botanical interest, the unexampled development and diversification of the genus Vaccinium (along with the allied American type, Gaylussacia) will attract attention. It is interesting to note the rapid falling away of Ericaceæ westward in the valley of the Mississippi as the forest thins out.

3. The wealth of this flora in Compositæ is a most obvious feature; one especially prominent at this season of the year, when the open grounds are becoming golden with Solidago, and the earlier of the autumnal Asters are beginning to blossom. The Compositæ form the largest order of Phænogamous plants in all temperate floras of the northern hemisphere, are well up to the average in Europe, but are nowhere so numerous as in North America, where they form an eighth part of the whole. But the contrast between the Compositæ of Europe and Atlantic North America is striking. Europe runs to Thistles, to Inuloideæ, to Anthemideæ, and to Cichoriaceæ. It has very few Asters and only two Solidagoes, no Sunflowers and hardly anything of that tribe. Our Atlantic flora surpasses all

the world in Asters and Solidagoes, as also in Sunflowers and their various allies, is rich in Eupatoriaceæ, of which Europe has extremely few, and is well supplied with Vernoniaceæ and Helenioideæ of which she has none; but is scanty in all the groups that predominate in Europe. I may remark that if our larger and most troublesome genera, such as Solidago and Aster, were treated in our systematic works even in the way that Nyman has treated Hieracium in Europe, the species of these two genera (now numbering 78 and 124 respectively) would be at least doubled.

4. Perhaps the most interesting contrast between the flora of Europe and that of the eastern border of North America is in the number of generic and even ordinal types here met with which are wholly absent from Europe. Possibly we may distinguish these into two sets of differing history. One will represent a tropical element, more or less transformed, which has probably acquired or been able to hold its position so far north in virtue of our high summer temperature. (In this whole survey the peninsula of Florida is left out of view, regarding its botany as essentially Bahaman and Cuban, with a certain admixture of northern elements.) To the first type I refer such trees and shrubs as Asimina, sole representative of the Anonaceæ out of the tropics, and reaching even to lat. 42°; Chrysobalanus, representing a tropical suborder; Pinckneya representing as far north as Georgia the Cinchoneous tribe; the Baccharis of our coast, reaching even to New England; Cyrilla and Cliftonia, the former actually West Indian; Bumelia, representing the tropical order Sapotaceæ; Bignonia and Tecoma of the Bignoniaceæ; Forestiera in Oleaceæ; Persea of the Laurineæ; and finally the Cactaceæ. Among the herbaceous plants of this set, I will allude only to some of peculiar orders. Among them I reckon Sarracenia (of which the only extra-North American representative is tropical-American, the Melastomaceæ, represented by Rhexia; Passiflora (our species being herbaceous), a few representatives of Loasaceæ and Turneraceæ, also of Hydrophyllaceæ; our two genera of Burmanniaceæ; three genera of Hæmodoraceæ; Tillandsia in Bromeliaceæ; two genera of Pontederiaceæ; two of Commelynaceæ; the outlying Mayaca and Xyris, and three genera of Eriocaulonaceæ. I do not forget that one of our species of Eriocaulon occurs on the west coast of Ireland and in Skye, wonderfully out of place, though on this side of the Atlantic it reaches Newfoundland. It may be a survival in the Old World; but it is more probably of chance introduction.

The other set of extra-European types, characteristic of the Atlantic North American flora, is very notable. According to a view which I have much and for a long while insisted on, it may be said to represent a certain portion of the once rather uniform flora of the arctic and less boreal zone, from the late Tertiary down to the incoming of the Glacial period, and which, brought down to our lower latitudes by the gradual refrigeration, has been preserved here in eastern North America and in the corresponding parts of Asia, but was lost to Europe. I need not recapitulate the evidence upon which this now generally accepted doctrine was founded; and to enumerate the plants which testify in its favor would amount to an enumeration of the greater part of the genera or subordinate groups of plants which distinguish our Atlantic flora from that of Europe. The evidence, in brief, is that the plants in question, or their moderately differentiated representatives, still co-exist in the flora of eastern North America and that of the Chino-Japanese region, the climates and conditions of which are very similar; and that the fossilized representatives of many of them have been brought to light in the late tertiary deposits of the arctic zone wherever explored. In mentioning some of the plants of this category I include the Magnolias, although there are no nearly identical species, but there is a seemingly identical Liriodendron in China, and the Schizandras and Illiciums are divided between the two floras; and I put into the list Menispermum, of which the only other species is eastern Siberian, and is hardly distinguishable from ours. When you call to mind the series of wholly extra-European types which are identically or approximately represented in the eastern North American and in the eastern Asiatic temperate floras, such as Trautvetteria and Hydrastis in Ranunculaceæ; Caulophyllum, Diphylleia, Jeffersonia and Podophyllum in Berberideæ; Brasenia and Nelumbium in Nymphæaceæ; Stylophorum in Papaveraceæ; Stuartia and Gordonia in Ternstromiaceæ; the equivalent species of Xanthoxylum, the equivalent and identical species of Vitis, and of the poisonous species of Rhus (one, if not both, of which you may meet with in every botanical excursion, and which it will be safer not to handle); the Horse-chestnuts, here called Buckeyes; the Negundo, a peculiar offshoot of the Maple tribe; when you consider that almost every one of the peculiar Leguminous trees mentioned as characteristic of our flora is represented by a species in China or Manchuria or Japan, and so of some herbaceous Leguminosæ; when you remember that the peculiar small order of which Calycanthus is the principal type has its other representative in the same region; that the species of Philadelphus, of Hydrangea, of Itea, Astilbe, Hamamelis, Diervilla, Triosteum, Mitchella which carpets the ground under evergreen woods, Chiogenes, creeping over the shaded bogs; Epigæa, choicest woodland flower of early spring; Elliottia; Shortia (the curious history of which I need not rehearse); Styrax of cognate species; Nyssa, the Asiatic representatives of which affect a warmer region; Gelsemium, which under the name of Jessamine is the vernal pride of the Southern Atlantic States; Pyrularia and Buckleya, peculiar Santalaceous shrubs; Sassafras and Benzoins of the Laurel family; Planera and Maclura; Pachysandra of the Box tribe; the great development of the Juglandaceæ (of which the sole representative in Europe probably was brought by man into southeastern Europe in pre-historic times); our Hemlock-Spruces, Arbor-vitæ, Chamæcyparis, Taxodium and Torreya, with their East Asian counterparts, the Roxburghiaceæ, represented by Croomia—and I might much further extend and particularize the enumeration—you will have enough to make it clear that the peculiarities of the one flora are the peculiarities of the other, and that the two are in striking contrast with the flora of Europe.

This contrast is susceptible of explanation. I have ventured to regard the two antipodal floras thus compared as the favored heirs of the ante-glacial high northern flora, or rather as the heirs who have retained most of their inheritance. For, inasmuch as the present arctic flora is essentially the same round the world, and the Tertiary fossil plants entombed in the strata beneath are also largely identical in all the longitudes, we may well infer that the ancestors of the present northern temperate plants were as widely distributed throughout their northern home. In their enforced migration southward geographical configuration and climatic differences would begin to operate. Perhaps the way into Europe was less open than into the lower latitudes of America and eastern Asia, although there is reason to think that Greenland was joined to Scandinavia. However that be, we know that Europe was fairly well furnished with many of the vegetable types that are now absent, possibly with most of them. Those that have been recognized are mainly trees and shrubs, which somehow take most readily to fossilization, but the herbaceous vegetation probably accompanied the arboreal. At any rate, Europe then possessed Torreyas and Gingkos, Taxodium and Glyptostrobus, Libocedrus, Pines of our five-leaved type, as well as the analogues of other American forms, several species of Juglans answering to the American forms, and the now peculiarly American genus Carya, Oaks of the American types, Myricas of the two American types, one or two Planer-trees, species of Populus answering to our Cotton-woods and our Balsam-poplar, a Sassafras and the analogues of our Persea and Benzoin, a Catalpa, Magnolias and a Liriodendron, Maples answering to ours, and also a Negundo, and such peculiarly American Leguminous genera as the Locust, Honey Locust, and Gymnocladus. To understand how Europe came to lose these elements of her flora, and Atlantic North America to retain them, we must recall the poverty of Europe in native forest trees, to which I have already alluded. A few years ago, in an article on this subject, I drew up a sketch of the relative richness of Europe, Atlantic North America, Pacific North America and the eastern side of temperate Asia in genera and species of forest trees.* In that sketch, as I am now convinced, the European forest-elements were somewhat under-rated. I allowed only 33 genera and 85 species, while to our Atlantic American forest were assigned 66 genera and 155 species. I find from Nyman's Conspectus that there are trees on the southern and eastern borders of Europe which I had omitted, that there are good species which I had reckoned as synonyms, and some that may rise to arboreal height which I had counted as shrubs. But on the other hand and for the present purpose it may be rejoined that the list contained several trees, of as many genera, which were probably carried from Asia into Europe by the hand of man. On Nyman's authority I may put into this category Cercis Siliquastrum, Ceratonia Siliqua, Diospyros Lotus, Styrax officinalis, the Olive, and even the Walnut, the Chestnut, and the Cypress. However this may be, it seems clear that the native forest flora of Europe is exceptionally poor, and that it has lost many species and types which once belonged to it. We must suppose that the herbaceous flora has suffered in the same way. I have endeavored to show how this has naturally come about. I cannot state it more concisely than in the terms which I used six years ago.

"I conceive that three things have conspired to this loss of American, or as we might say, of normal types sustained by Europe. First, Europe, extending but little south of lat. 40°, is all within the limits of severe glacial action. Second, its mountains trend east and west, from the Pyrenees to the Carpathians and the Caucasus beyond: they had glaciers of their own, which must have begun their work and poured down the northward flanks while the plains were still covered with forest on the retreat from the great ice forces coming from the north. Attacked both on front and rear, much of the forest must have perished then and there.

"Third, across the line of retreat of whatever trees may have flanked the mountain ranges, or were stationed south of them, stretched the Mediterranean, an impassible barrier. . . Escape by the east, and rehabilitation from that quarter until a very late period, was apparently prevented by the prolongation of the Mediterranean to the Caspian, and probably thence to the Siberian Ocean. If we accept the supposition of Nordenskiöld that, anterior to the Glacial period, Europe was 'bounded on the south by an ocean extending from the Atlantic over the present deserts of Sahara and Central Asia to the Pacific,' all chance of these American types having escaped from and reëntered Europe from the south and east seems excluded. Europe may thus be conceived to have been for a time somewhat in the condition in which Greenland is now. . . . Greenland may be referred to as a country which, having undergone extreme glaciation, bears the marks of it in the extreme poverty of its flora, and in the absence of the plants to which its southern portion, extending six degrees below the arctic circle, might be entitled. It ought to have trees and it might support them. But since their destruction by glaciation no way has been open for their return. Europe fared much better, but has suffered in its degree in a similar way."*

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* This Journal, III, xvi, 85.

Turning to this country for a contrast, we find the continent on the eastern side unbroken and open from the arctic circle to the tropic, and the mountains running north and south. The vegetation when pressed on the north by on-coming refrigeration had only to move its southern border southward to enjoy its normal climate over a favorable region of great extent; and, upon the recession of glaciation to the present limit, or in the oscillations which intervened, there was no physical impediment to the adjustment. Then, too, the more southern latitude of this country gave great advantage over Europe. The line of terminal moraines, which marks the limit of glaciation rarely passes the parallel of 40° or 39°. Nor have any violent changes occurred here, as they have on the Pacific side of the continent, within the period under question. So, while Europe was suffering hardship, the lines of our Atlantic American flora were cast in pleasant places, and the goodly heritage remains essentially unimpaired.

The transverse direction and the massiveness of the mountains of Europe, while they have in part determined the comparative poverty of its forest-vegetation, have preserved there a rich and widely distributed alpine flora. That of Atlantic North America is insignificant. It consists of a few arctic plants, left scattered upon narrow and scattered mountain-tops, or in cool ravines of moderate elevation; the maximum altitude is only about 6,000 feet in lat. 44°, on the White Mountains of New Hampshire, where no winter snow outlasts midsummer. The best alpine stations are within easy reach of Montreal. But as almost every species is common to Europe, and the mountains are not magnificent, they offer no great attraction to a European botanist.

Farther south, the Appalachian Mountains are higher, between lat. 36° and 34° rising considerably above 6,000 feet; they have botanical attractions of their own, but they have no alpine plants. A few subalpine species linger on the cool shores of Lake Superior, at a comparatively low level. Perhaps as many are found nearly at the level of the sea on Anticosti, in the Gulf of St. Lawrence, abnormally cooled by the Labrador current.

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* This Journal, l. c., 194.

The chain of great fresh-water lakes, which are discharged by the brimming St. Lawrence, seems to have little effect upon our botany, beyond the bringing down of a few northwestern species. But you may note with interest that they harbor sundry maritime species, mementoes of the former saltness of these interior seas. Cakile Americana, much like the European Sea Rocket, Hudsonia tomentosa (a peculiar Cistaceous genus imitating a Heath), Lathyrus maritimus, and Ammophila arenaria are the principal. Salicornia, Glaux, Scirpus maritimus, Ranunculus Cymbalaria, and some others may be associated with them. But these are widely diffused over the saline soil which characterizes the plains beyond our wooded region.

I have thought that some general considerations like these might have more interest for the biological section at large than any particular indications of our most interesting plants, and of how and where the botanist might find them. Those who in these busy days can find time to herborize will be in the excellent hands of the Canadian botanists. At Philadelphia their brethren of "the States" will be assembled to meet their visitors, and the Philadelphians will escort them to their classic ground, the Pine Barrens of New Jersey. To have an idea of this peculiar phytogeographical district, you may suppose a long wedge of the Carolina coast to be thrust up northward quite to New York harbor, bringing into a comparatively cool climate many of the interesting low-country plants of the South, which, at this season, you would not care to seek in their sultry proper home. Years ago, when Pursh and Leconte and Torrey used to visit it, and in my own younger days, it was wholly primitive and unspoiled. Now, when the shore is lined with huge summer hotels, the Pitch Pines carried off for firewood, the bogs converted into cranberry-grounds, and much of the light sandy or gravely soil planted with vineyards or converted into melon and sweet-potato patches, I fear it may have lost some of its botanical attractions. But large tracts are still nearly in a state of nature. Drosera filiformis, so unlike any European species, and the beautiful Sabbatias, the yellow Fringed Orchises, Lachnanthes and Lophiola, the larger Xyrises and Eriocaulons, the curious grass Amphicarpum with cleistogamous flowers at the root, the showy species of Chrysopsis, and many others, must still abound. And every botanist will wish to collect Schizæa pusilla, rarest, most local, and among the smallest of Ferns.

If only the season would allow it, there is a more southern station of special interest,—Wilmington, on the coast of North Carolina. Carnivorous plants have, of late years, excited the greatest interest, both popular and scientific, and here, of all places, carnivorous plants seem to have their most varied develment. For this is the only and the very local home of Dionæa; here grow almost all the North American species of Drosera; here or near by are most of the species of Sarracenia, of the bladder-bearing Utricularias,—one of which the President of our Section has detected in fish-catching,—and also the largest species of Pinguicula.

But at this season a more enjoyable excursion may be made to the southern portion of the Alleghany or Appalachian Mountains, which separate the waters of the Atlantic side from those of the Mississippi. These mountains are now easily reached from Philadelphia. In Pennsylvania, where they consist of parallel ridges without peaks or crests, and are of no great height, they are less interesting botanically than in Virginia; but it is in North Carolina and the adjacent borders of Tennessee that they rise to their highest altitude, and take on more picturesque forms. On their sides the Atlantic forest, especially its deciduous-leaved portion, is still to be seen to greatest advantage, nearly in pristine condition, and composed of a greater variety of genera and species than in any other temperate region, excepting Japan. And in their shade are the greatest variety and abundance of shrubs, and a good share of the most peculiar herbaceous genera. This is the special home of our Rhododendrons, Azaleas, and Kalmias; at least here they flourish in greatest number and in most luxuriant growth. Rhododendron maximum (which is found in a scattered way even as far north as the vicinity of Montreal) and Kalmia latifolia (both called Laurels) even become forest trees in some places; more commonly they are shrubs, forming dense thickets on steep mountain-sides, through which the traveler can make his way only by following old bear-paths, or by keeping strictly on the dividing crests of the leading ridges.

Only on the summits do we find Rhododendron Catawbiense, parent of so many handsome forms in English grounds, and on the higher wooded slopes the yellow and the flame-colored Azalea calendulacea: on the lower, the pink A. nudiflora and more showy A. arborescens, along with the common and wide-spread A. viscosa. The latter part of June is the proper time to explore this region, and, if only one portion can be visited, Roan Mountain should be preferred.

On these mountain tops we meet with a curious anomaly in geographical distribution. With rarest exceptions, plants which are common to this country and to Europe extend well northward. But on these summits from southern Virginia to Carolina, yet nowhere else, we find—undoubtedly indigenous and undoubtedly identical with the European species—the Lily-of-the-Valley!

I have given so much of my time to the botany of the Atlantic border that I can barely touch upon that of the western regions.

Between the wooded country of the Atlantic side of the continent and that of the Pacific side lies a vast extent of plains which are essentially woodless, except where they are traversed by mountain-chains. The prairies of the Atlantic States bordering the Mississippi and of the Winnipeg country shade off into the drier and gradually more saline plains, which, with an even and gradual rise, attain an elevation of 5,000 feet or more where they abut against the Rocky Mountains. 'Until these are reached (over a space from the Alleghanies westward of about twenty degrees of longitude) the plains are unbroken. To a moderate distance beyond the Mississippi the country must have been in the main naturally wooded. There is rainfall enough for forest on these actual prairies. Trees grow fairly well when planted; they are coming up spontaneously under present opportunities; and there is reason for thinking that all the prairies east of the Mississippi, and of the Missouri up to Minnesota, have been either greatly extended or were even made treeless under Indian occupation and annual burnings. These prairies are flowery with a good number of characteristic plants, many of them evidently derived from the plains farther west. At this season, the predominant vegetation is of Compositæ, especially of Asters and Solidagoes, and of Sunflowers, Silphiums, and other Helianthoid Compositæ.

The drier and barer plains beyond, clothed with the short Buffalo-Grasses, probably never bore trees in their present state, except as now some Cottonwoods (i. e. Poplars) on the margins of the long rivers which traverse them in their course from the Rocky Mountains to the Mississippi. Westward, the plains grow more and more saline; and Wormwoods and Chenopodiaceæ of various sorts form the dominant vegetation, some of them *sui generis* or at least peculiar to the country, others identical or congeneric with those of the steppes of northern Asia. Along with this common campestrine vegetation, there is a large infusion of peculiar American types, which I suppose came from the southward, and to which I will again refer.

Then come the Rocky Mountains, traversing the whole continent from north to south; their flanks wooded, but not richly so,—chiefly with Pines and Firs of very few species, and with a single ubiquitous Poplar, their higher crests bearing a well-developed alpine flora. This is the arctic flora prolonged southward upon the mountains of sufficient elevation, with a certain admixture in the lower latitudes of types pertaining to the lower vicinity.

There are almost 200 alpine Phænogamous species now known on the Rocky Mountains; fully three-quarters of which are arctic, including Alaskan and Greenlandian; and about half of them are known in Europe. Several others are North Asian but not European. Even in that northern portion of the Rocky Mountains which the Association is invited to visit, several alpine species novel to European botany may be met with; and farther south the peculiar forms increase. On the other hand, it is interesting to note how many Old-World species extend their range southward even to lat. 36° or 35°.

I have not seen the Rocky Mountains in the Dominion: but I apprehend that the aspect and character of the forest is Canadian, is mainly coniferous, and composed of very few species. Oaks and other cupuliferous trees, which give character to the Atlantic forest, are entirely wanting, until the southern confines of the region are reached in Colorado and New Mexico, and there they are few and small. In these southern parts there is a lesser amount of forest, but a much greater diversity of genera and species; of which the most notable are the Pines of the Mexican plateau type.

The Rocky Mountains and the Coast Ranges on the Pacific side so nearly approach in British America that their forests merge, and the eastern types are gradually replaced by the more peculiar western. But in the United States a broad, arid and treeless, and even truly desert region is interposed. This has its greatest breadth and is best known where it is traversed by the Central Pacific Railroad. It is an immense plain between the Rocky Mountains and the Sierra Nevada, largely a basin with no outlet to the sea, covered with Sage-brush (i. e. peculiar species of Artemisia) and other subsaline vegetation, all of grayish hue; traversed, mostly north and south, by chains of mountains, which seem to be more bare than the plains, but which hold in their recesses a considerable amount of forest and of other vegetation, mostly of Rocky Mountain types.

Desolate and desert as this region appears, it is far from uninteresting to the botanist; but I must not stop to show how. Yet even the ardent botanist feels a sense of relief and exultation when, as he reaches the Sierra Nevada, he passes abruptly into perhaps the noblest coniferous forest in the world,—a forest which stretches along this range and its northern continuation, and along the less elevated ranges which border the Pacific coast, from the southern part of California to Alaska.

So much has been said about this forest, about the two gigantic trees which have made it famous, and its Pines and Firs which are hardly less wonderful, and which in Oregon and British Columbia, descending into the plains, yield far more timber to the acre than can be found anywhere else, and I have myself discoursed upon the subject so largely on former occasions, that I may cut short all discourse upon the Pacific coast flora and the questions it brings up.

I note only these points. Although this flora is richer than that of the Atlantic in Coniferæ (having almost twice as many species), richer indeed than any other except that of Eastern Asia, it is very meagre in deciduous trees. It has a fair number of Oaks, indeed, and it has a Flowering Dogwood, even more showy than that which brightens our eastern woodlands in spring. But, altogether it possesses only one-quarter of the number of species of deciduous trees that the Atlantic forest has; it is even much poorer than Europe in this respect. It is destitute not only of the characteristic trees of the Atlantic side, such as Liriodendron, Magnolia, Asimina, Nyssa, Catalpa, Sassafras, Carya, and the arboreous Leguminosæ (Cercis excepted), but it also wants most of the genera which are common throughout all the other northern-temperate floras, having no Lindens, Elms, Mulberries, Celtis, Beech, Chestnut, Hornbeam, and few and small Ashes and Maples. The shrubbery and herbaceous vegetation, although rich and varied, is largely peculiar, especially at the south. At the north we find a fair number of species identical with the eastern; but it is interesting to remark that this region, interposed between the N. E. Asiatic and the N. E. American and with coast approximate to the former, has few of those peculiar genera which, as I have insisted, witness to a most remarkable connection between two floras so widely sundered geographically. Some of these types, indeed, occur in the intermediate region, rendering the general absence the more noteworthy. And certain peculiar types are represented in single identical species on the coasts of Oregon and Japan, etc., (such as Lysichiton, Fatsia, Glehnia); yet there is less community between these floras than might be expected from their geographical proximity at the north. Of course the high northern flora is not here in view.

Now if, as I have maintained, the eastern side of North America and the eastern side of Northern Asia are the favored heirs of the old boreal flora, and if I have plausibly explained how Europe lost so much of its portion of a common inheritance, it only remains to consider how the western side of North America lost so much more. For that the missing types once existed there, as well as in Europe, has already been indicated in the few fossil explorations that have been made. They have brought to light Magnolias, Elms, Beeches, Chestnut, a Liquidambar, etc. And living witnesses remain in the two Sequoias of California, whose ancestors, along with Taxodium, which is similarly preserved on the Atlantic side, appear to have formed no small part of the Miocene flora of the arctic regions.

Several causes may have conspired in the destruction;—climatic differences between the two sides of the continent, such as must early have been established (and we know that a difference no greater than the present would be effective); geographical configuration, probably confining the migration to and fro to a long and narrow tract, little wider, perhaps, than that to which it is now restricted; the tremendous outpouring of lava and volcanic ashes just anterior to the Glacial period, by which a large part of the region was thickly covered; and, at length competition from the Mexican plateau vegetation,—a vegetation beyond the reach of general glacial movement from the north, and climatically well adapted to the southwestern portion of the United States.

It is now becoming obvious that the Mexican plateau vegetation is the proximate source of most of the peculiar elements of the Californian flora, as also of the southern Rocky Mountain region and of the Great Basin between; and that these plants from the south have competed with those from the north on the eastward plains and prairies. It is from this source that are derived not only our Cacteæ but our Mimoseæ, our Daleas and Petalostemons, our numerous and varied Onagraceæ, our Loasaceæ, a large part of our Compositæ, especially the Eupatoriaceæ, Helianthoideæ, Helenioideæ, and Mutisiaceæ, which are so characteristic of the country, the Asclepiadeæ, the very numerous Polemoniaceæ, Hydrophyllaceæ, Eriogoneæ, and the like.

I had formerly recognized this element in our North American flora; but I have only recently come to apprehend its full significance. With increasing knowledge we may in a good measure discriminate between the descendants of the ancient northern flora, and those which come from the highlands of the southwest.

Art. XL.—*Columbite in the Black Hills of Dakota*; by Wm. P. Blake.

Columbite associated with cassiterite, albite and mica occurs in several of the coarsely crystalline granite dikes which traverse the mica schists and sandstones of Pennington County, Dakota. The most notable localities are at the Etta mining claim and at the Ingersoll, about ten miles east of Harney Peak. At the Ingersoll claim, particularly, a mass of unusual dimensions was found protruding from a matrix of albite and quartz. This mass consisted of nearly pure columbite with here and there inclusions of thin sheets of quartz. It measured, approximately, twenty inches square by twenty-four in length, weighing by calculation, taking the specific gravity at 6, not less than 2000 pounds, or one ton. On blasting it out it broke up generally into tabular fragments without crystalline planes except at the lower or imbedded end where it was enclosed in quartz, into which it penetrated in thin, tabular crystals with brilliant prismatic and terminal planes. At the Etta on the contrary, the best crystals are taken from the albite and are more distinct and separate than at the Ingersoll claim. The habit of the Ingersoll crystals is thin and tabular with acute, wedge-like prismatic edges; the plane $i\text{-}\breve{2}$ being nearly obliterated by the extension of the planes $i\text{-}\breve{3}$ and I, while at the Etta these planes are subordinate to the plane $i\text{-}\breve{2}$ and $i\text{-}\bar{2}$. The terminal plane O is generally narrow in the crystals from both localities, and is flanked by a series of bevelling planes like those in the Greenland crystals, $\frac{1}{8}\text{-}\bar{2}$ being especially prominent.

In breaking up the large mass I found several cavities filled with a beautiful yellow powder often in pellets and pill-like balls. These prove to be chiefly hydrous uranium oxide without sulphuric or carbonic acid. A similar mineral occurs at the Etta but gives different reactions.

The blow-pipe reactions of the columbite from the Ingersoll claim are peculiar in the amount of manganese indicated. With borax, in O.F. the bead is dark amethystine red, and in R.F. a pale amber yellow. The purity of this reaction for manganese is not impaired by any other metallic reaction. With phosphate of soda and ammonia in O.F. the mineral dissolves to a clear glass, red while hot, yellowish-red while cooling, and when cold clear and nearly colorless, with a pale rose-colored or amethystine tint. In R.F. the bead is beautiful amber-yellow and there is no shade of green or reaction for uranium. On foil the manganese reaction is distinct. Treated with concentrated sulphuric acid and evaporated to dryness the powdered mineral is partially decomposed. With the addition of a second portion of acid the solution gives with zinc the intense sapphire-blue reaction.

Pine Forest Camp, September 25, 1884.

ART. XLI.—*A Spectro-photometric Study of Pigments*; by EDWARD L. NICHOLS, Ph.D.

[Read at the Philadelphia meeting of the American Association for the Advancement of Science.]

THE usual methods of determining the three so-called constants of color—hue, purity and luminosity—are open to serious question. If the light reflected by pigments were nearly monochromatic, the comparison of their colors with the tints of the solar spectrum would offer no difficulty and the wave-length would afford a most convenient measure of the hue. The spectroscope shows, however, that pigments cannot be considered even in the roughest approximation as reflecting monochromatic light. They exhibit continuous spectra in which are present a large proportion of the rays of the visible spectrum of white light. They do not owe their color to the presence of well defined bright lines or bands, nor to the absence of particular wave-lengths, but to the manner in which the intensity of different portions of their spectra varies with the wave-length. Their color is much more nearly akin to white, of which indeed it may very properly be considered a modification, than it is to any monochromatic tint, and the attempt to compare the combined effect of all the rays reflected to the eye by a pigment with that produced by any single wave-length of the solar spectrum cannot but prove unsatisfactory. It is often possible, nevertheless, to decide upon a particular region as matching the pigment more nearly than any other, but owing to the difference in eyes all observers do not select the same wave-length and the comparison serves better to exhibit peculiarities of color-perception than to indicate the character of the pigment.

It is found that by mixing with white light the portion of the spectrum corresponding most nearly to a pigment in hue, the resemblance is increased. The purity of the pigment is determined by the amount of white light which gives the nearest approach to identity; to which amount under the usual, but untenable, assumption that the light reflected by pigments is a mixture of white and monochromatic light, it is in inverse proportion.

The usual method of determining the luminosity is even more questionable. That the brightness of two surfaces is comparable only when they are of the same color is a universally accepted principle in photometry. Even slight differences of tint introduce an element of uncertainty, and methods which involve the comparison of a neutral gray surface with those presented by deeply tinted pigments cannot but be regarded with doubt.

It may be urged in favor of the use of these three constants of color that the methods just alluded to have led to fairly accordant results, have increased very much our knowledge of the properties of pigments, and have given us a means of describing colors and distinguishing between them which however artificial and faulty cannot well be dispensed with. If the subject were such as to preclude the adoption of a more scientific and complete method of determining the character of the light reflected by non-luminous bodies, there would be less force to the objections just offered to the present system. The question of a better method is however not so complex as it may seem at first sight. It resolves itself from the nature of the case into a perfectly definite problem; to determine what wave-lengths are present in the spectrum of the light reflected by the object in question, and to measure the intensity of each wave-length.

The use of the spectroscope in mapping spectra leaves nothing to be desired in the determination of the wave-length, the methods in vogue in the study of absorption spectra being equally adapted to the investigation of the reflected rays. The addition to the spectroscope of parts which shall make it possible to measure the intensity of all portions of a spectrum as readily as we determine the wave-length, will enable us to substitute for the present system of questionable color-constants a perfectly definite and complete statement of the wave-length and intensity of the rays emanating from any object whether viewed by transmitted or by reflected light.

An instrument which fulfills these requirements is a modification of the spectro-photometer used by the writer in 1878 in the study of the spectrum of glowing platinum.[1] Like the spectro-photometers of Vierordt[2] and Glan[3] it depends upon the sensitiveness of the eye to small differences in the brightness of neighboring surfaces of identical color; a property which enables the observer to decide with great certainty when two portions of a field of view, which is of one tint throughout, but the two halves of which can be varied in intensity at will, are equally bright.

In front of the slit of an ordinary one-prism spectroscope (see fig. 1) a right angled prism (P) is placed, with its edge perpendicular to the slit (S) and bisecting it, and its longest face extending downward and outward at an angle of 45.°

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[1] Ueber das von glühendem Platin ausgestrahlte Licht, Göttingen 1879. Also this Journal, Dec. 1879 and Jan., 1880.

[2] Vierordt, Poggendorff's Annalen, vol. cxl.

[3] Glan, Wiedemann's Annalen, vol. i.

Rays coming vertically from below this prism are totally reflected by it and pass through the lower half of the slit, the collimator and the dispersing prism of the spectroscope. The light reflected from any object placed beneath the reflecting prism thus produces a spectrum, which occupies the upper half of the field of view of the inverting telescope. Before the upper half of the slit is placed a Nicol's prism (N) with the longer diagonals of its faces vertical, the optical axis being parallel to the axis of the collimator tube. Light passing through this Nicol and through the upper half of the slit, the collimator and dispersing prism forms a spectrum just below the first one (in the field of view). The boundary between the two spectra is the sharply defined image of the edge of the reflecting prism where it bisects the slit. The second spectrum is polarized in a vertical plane: the first one is unpolarized. A diaphragm (D) in the eye-piece of the spectroscope, by means of which vision may be confined to the region under observation, and a second Nicol (O), next the eye, complete the spectro-photometer. The second or "ocular Nicol" is free to revolve, and its position is indicated by a pointer (I) moving upon a graduated circle (C).

1.

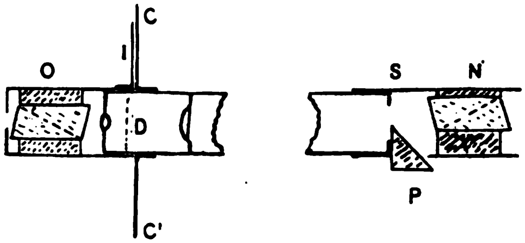
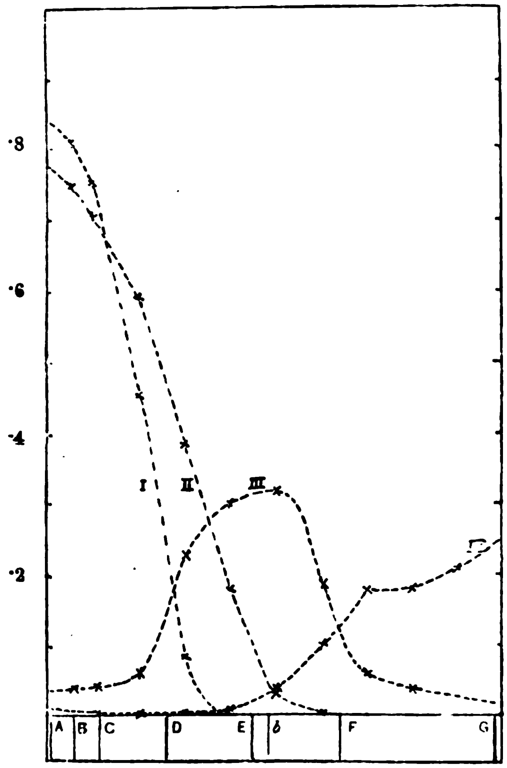


Diagram showing the eye-piece and slit of the spectro-photometer, with the adjoining parts.

In order to compare the spectrum of the light reflected by any object with the spectrum of daylight, the object is placed below the reflecting prism and illuminated either by the direct rays of the sun or by diffuse daylight. Before the polarizing Nicol a white sheet of paper or a plane mirror reflecting light from the sky, furnishes the polarized spectrum. It is possible by rotating the ocular Nicol to give this spectrum any intensity between that which it possesses when the polarizing planes of the two Nicols are parallel and that at which it becomes too faint to be visible. Whatever be the character of the light reflected by the object to be studied, it is therefore possible to find a position of the ocular Nicol for which the region of the spectrum under observation and the corresponding wave-length of the polarized spectrum are equally bright. From the angle between the planes of polarization of the two Nicols can then be calculated the ratio between the intensities of the two spectral regions when the polarized spectrum is at its maximum; and a series of measurements of the variation of the intensity with the wave-length may be obtained, in which the intensity of each region is expressed in terms of the intensity of the corresponding wave-length in the spectrum of daylight.

In studying the spectra of a variety of substances it is necessary, in order to bring them to a common scale, to adopt some

2.



Curves showing the intensity of the spectra of four pigments (I, red lead; II, chromate of lead; III, chromic oxide; IV, ultramarine). Abscissæ are wave-lengths. Ordinates are intensities.

standard of color and of luminosity; for which purpose a pigment presenting a neutral white surface is most suitable. By comparing the spectrum of this white surface with the polarized spectrum under precisely the same conditions as those under which each pigment is compared, all measurements can be referred to a common unit, i. e. to the intensity of a certain region of this spectrum; or, as is generally more convenient, each region in the spectra of the pigments can be referred to the intensity of the corresponding wave-length in this standard spectrum.

To test the efficacy of this method four characteristic pigments were selected. These were red-lead, chromate of lead, chromic oxide and artificial ultramarine. The red and blue were the usual commercial preparations. They showed well formed crystals under the microscope. The yellow and green were freshly prepared by precipitation and the separate particles could not be distinguished with a ¼ inch objective. These dry pigments were spread to a depth of about 10^{mm} upon a black surface. They were not subjected to any considerable pressure. Powdered magnesium carbonate treated in the same manner served as the standard white. The spectrum of the light reflected from the rather uneven surfaces thus obtained was compared with the spectrum of daylight. The measurements, the results of which are exhibited in the above table and by the accompanying curves (figure 2) were made for the most part by the writer's assistant, Mr. W. S. Franklin. Each value is the mean of ten or more readings. The portions of the spectrum in which measurements were made are designated by their characteristic colors. The wave-lengths are

TABLE.

Region.		Intensity referred to that of the corresponding wave-length of the spectrum of white light.				Intensity referred to that of the region of the D line in the spectrum of white light.				
Color. (Rood.*)	Wave-length.	Red lead.	Chromate of lead.	Chromic oxide.	Ultramarine.	Red lead.	Chromate of lead.	Chromic oxide.	Ultramarine.	White. (Lamansky.)†
Red, ...	6800	0·815	0·744	0·042	....	1·158	1·056	0·060	....	1·421
Orange-red, ...	6550	0·747	0·718	0·046	0·005	0 996	0·957	0·062	0·007	1·333
Orange, ...	5950	0·452	0·587	0·061	0·004	0·515	0·670	0 068	0·005	1·114
Yellow, ...	5680	0·077	0·371	0·223	0·006	0 073	0·352	0·211	0·005	0·947
Yellow-green, ...	5370	....	0·170	0·297	0·009	....	0·132	0·232	0·006	0·781
Green, ...	5200	....	0·026	0·322	0·034	....	0·017	0·225	0·021	0·649
Green-blue, ...	4910	....	0·001	0·184	0·110	....	0·001	0·092	0·055	0·500
Cyan-blue, ...	4700	....	....	0·064	0·181	..	....	0·026	0·072	0·400
Blue, ...	4580	....	....	0·045	0·182	....	....	0·013	0·055	0·303
Violet-blue, ...	4410	....	....	....	0·210	....	....	....	0·047	0·225
Violet, ...	4330	....	....	....	....	....	....	....	....	0·106

* Rood, Modern Chromatics, p. 26.

† Lamansky (article already cited).

given in ten millionths of a millimeter. The first set of values given in the table are referred to the corresponding intensities of the standard spectrum; the second set are all referred to the intensity of the region of the D line in the standard spectrum, the well known measurements of the intensities of the solar-spectrum by Lamansky[1] being used in the reduction.

The curves (figure 2) accompanying the foregoing table represent graphically the results of this method as applied to the four pigments in question. The abscissæ are wave-lengths, the ordinates are intensities and the curves show the distribution of energy throughout the prismatic spectrum. They are identical with the curves which would be obtained by exploring the spectra of the pigments with a sufficiently delicate thermopile, and do not represent the optical effect which is a complicated function of the energy of the ray, the character of which is not the same for all wave-lengths nor for all eyes. An inspection of these curves verifies the opinion expressed in the first paragraph of this paper, that pigments are more nearly related to white than to any monochromatic color, and that the attempt to express the hue of non-luminous bodies by comparison with isolated spectral tints is founded upon a false conception of the nature of the light which they reflect. To determine the hue of a pigment from the analysis of the light it reflects is a problem in physiological optics the solution of which varies with the character of the observer's eye. The three primary color-curves of the eye must be determined and the total intensity of each wave-length of the spectrum of the pigment must be divided in the proportions indicated by the color-curves into three components; red, green and violet. Summing up each of these components for the entire spectrum we obtain an expression for the hue in terms of the three primary color-sensations of which it is the resultant. In default of this method, which is difficult of execution, the curves themselves are an expression of the hue, the only requisite for the interpretation of which is practice in associating the sensation of color produced by pigments with the form of curve representing them.

If we retain as the standard of purity the monochromatic tint, the intensity-curve of a perfectly pure color is a vertical line, the position of which in the spectrum indicates the hue and the length of which shows the brightness of the color. Variations from this form, in the intensity-curves of pigments, exhibit at once the kind and degree of the impurity. The intensity-curves for red-lead, chrome-yellow, chrome-green and ultramarine blue all serve to show, that purity cannot properly be measured by supposing the pigment to consist of a monochromatic tint plus a certain amount of white light, and that the only satisfactory method of indicating this property of pigments is by giving in some convenient unit the wave-lengths and the intensity of each wave-length of their spectra.

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[1] Lamansky, Poggendorff's Annalen cxli.

As regards luminosity the curves afford two kinds of information. The ordinate of each wave-length gives the brightness of that wave-length, as compared with the brightness of the corresponding wave-length in the spectrum of the standard white. The area enclosed by a curve and by the coördinates, between the origin and the points where the curve cuts the coördinates, is a measure of the total energy of the visible rays reflected by the pigment, as compared with those reflected by the standard white. These ratios stand in a definite relationship to the luminosity of the color, but they are independent of the peculiarities of individual eyes and they are in this respect a better measure of the brightness of the color.

University of Kansas, July 12, 1884.

ART. XLII.—*A Criticism of Becker's Theory of Faulting;* by

ROSS E. BROWNE, M. Tech. Soc.

[Read July 11, 1884, before the Technical Society of the Pacific Coast.][*]

Mr. BECKER says: "The evidence of faulting on the Comstock is manifold, etc." "Both to the east and west of the vein, too, the country rock shows a rude division into sheets, and along the partings between the plates evidences of movement are perceptible, decreasing in amount as the distance from the vein increases, according to some law not directly inferable." "Each sheet appears to have risen relatively to its eastern neighbor, and to have sunk as compared with the sheet adjoining it on the west. The consideration of a sheet or plate of rock under the influence of friction of a relatively opposite character on its two faces, therefore, forms the natural starting point for an examination of the observed conditions. It is shown in Chapter IV that if a country divided like the Comstock area into parallel sheets experiences a dislocation on one of the partings under a compressive strain equal at each parting, a vertical cross-section will show a surface line represented by two logarithmic equations."

"Where a fault of the class under discussion has occurred, and where the resulting surface has not been obscured by deep erosion, the original surface can be reconstructed or calculated, and the amount of dislocation determined."

"The theory, though worked out independently of the Comstock, applies to it with much precision. Equations can be given representing very closely the surface line of a cross-section, the amount of the fault can be determined, etc."

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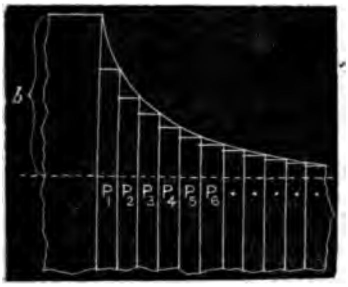
[*] See "Monographs of the U. S. Geological Survey, 1882;" vol. iii, on the Comstock Lode, etc., by George F. Becker; chapter iv, on Structural Results of Faulting.

The above quotations from the summary, pp. 376–380, are made in order to bring before the reader, as briefly as such means will permit, some of the prominent features of the theory which it is proposed to criticise.

In the discussion under the several headings, "Transmission of energy by friction," "Distribution of energy through a system of sheets," "The velocities of moving sheet, etc.," there appears a misconception of an important question involved.

Mr. Becker says if sheet W (see fig. 1) "begins its motion with a fixed quantity of energy, and if P_1 is fixed, the entire energy will ultimately be expended in heat, sound, etc., on the contact. But if P_1 is movable a portion of the energy of W will be communicated to P_1, etc."*

1.



These statements are true, but it must be borne in mind, that in effect, the force of friction is simply a resistance to *relative* motion. If P_1 offers greater resistance to a relative movement of W than the body of sheets to the right offers to a relative movement of P_1, it follows that relative rest between W and P_1 will not be disturbed, and the latter will move with the full velocity of the former.† If P_1 is initially at rest, it will either remain at rest or acquire the full velocity of W.

"If P_1 is in contact with a third plate or sheet P_2 the energy received by P_1 will be expended wholly or in part in overcoming the resistance on the contact P_1 P_2." It should be kept in view that if P_2 moves at all, it does so with the full velocity of P_1, for the reasons above given. "If these sheets are the earlier members of a series of sheets W, P_1, P_2, P_3, ... of indefinite number, then each sheet which moves will communicate a certain amount of energy to the next, and since the resistance of friction* is proportional to the distance through which it acts, each sheet which receives energy from its predecessor must move."

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* The pressure exerted by W upon P_1, was considered as uniformly distributed —see * page 351.

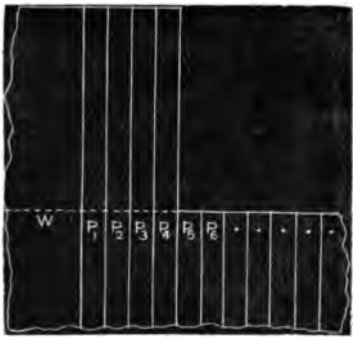
† This statement apparently calls for some qualification, for if a considerable velocity is suddenly imparted to W, and the resistance mentioned means simply frictional resistance, the inertia of P_1 will give rise to a dislocation at contact W P_1. However, if the most reasonable conditions are imposed—if the acceleration of W is supposed to be small, and there is assumed to be a material difference between the frictional resistance which P_1 offers to motion of W and that which the body of the sheet to the right offers to motion of P_1—it is proper to consider that the resistance which the mass of P_1 offers to motion will not cause dislocation, but will result in vibrations in the elastic sheets transmitted through the projections at the contact. It is not supposed that it was Mr. Becker's intention to consider any appreciable velocity as being suddenly acquired. The "fixed quantity of energy," with which W begins its motion, cannot be energy of motion (kinetic energy).

In other words, each such sheet must be translated. Herein lies the misconception. If the resistance, which a given sheet P_5 offers to motion, is greater than the resistance it causes to the motion of its predecessor P_4, it will remain at rest; and though it receives energy from its predecessor this energy is in the form of heat and will not cause translation of P_5.

Now follows this statement: "Since the sheets are in all respects alike and the pressure at each contact is the same, the frictional resistance or negative force at each contact will also be the same, etc."

This is an astonishing condition to impose, as it could never be realized (not even with carefully prepared sheets of paper), and to say that it could be realized approximately would but show a misunderstanding of the problem. Any small difference between the surfaces of contact, of a nature to influence friction, would change the character of the problem. There would be one contact where the frictional resistance would be less than at the other contacts and here only would there occur a dislocation. If the condition should nevertheless be entertained, there would, owing to the inertia of P_1, result a dislocation at the first contact W P_1. The sheets P_1, P_2, P_3, ... would all remain at rest, though in unstable equilibrium.

2.



In the real question at issue, then, if the contact between P_4 and P_5 offers less resistance than the other contacts, motion of W will simply produce the effect shown in fig. 2, and not the effect claimed by Mr. Becker and shown in fig. 1.

It would be purposeless to follow the mathematical developments erratically based upon this misconception of the main question involved. Suffice it to say that a logarithmic equation is reached to represent the supposed curve. However, some comment upon the "experimental verification" will not be out of place. Under this heading the author says:

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* Probably "work of friction" is meant.

: the various assumptions made are correct, a fault under n conditions will result in a surface, a vertical section of ı at right angles to the strike of the fault will present a ithmic curve. Before proceeding to any further deductions, evidently desirable to test the correctness of the postulates imentally. I have supposed the sheets of rock of infinite ıs compared with their exposed margins, because on this sition the pressure per unit of area of each parting will be ame.* If the plates were thoroughly flexible, and if the ure were applied on a limited zone parallel to the croppings emoved by a distance greater than *b* from either end of the s, then the pressure exerted on each plate would be the same, would be distributed over an equal area, and the resulting would still answer to the general formula deduced.† These tions we can approximately reproduce. If a pile of, say, one red slips of very thin, flexible and uniform paper, eight or ıches long, with sharply cut edges, are laid upon a flat surand a narrow weight of three or four pounds is placed across , the pressure under the weight may be considered as con- In the experiments I have made, the weight employed ıbout 5,000 times as great as that of a single slip. If a blunt such as that of a ruler,‡ be now applied at right angles to nger dimension of the slips, close to the weight, with a light ure, and be drawn away from the weight a fraction of an a slight relative movement will be perceptible. If this cation of energy to the system be repeated a score of times, nds of the pile of slips would be found to form a curved surnstead of a plane. If the frictional resistance is proportional e pressure, this curve must sensibly coincide with that given e equation

$$y=\frac{Am^{-x}}{1+xt},\text{" etc.}$$

the above directions are followed, the pressure applied the ruler being made sufficient, a curve will be produced; t is significant that a blunt edged tool is used for the pur-

If "the pressure per unit of area of each parting" is to en approximately the same throughout each parting, why istribute the weight uniformly over the upper slip, fasten e same, and move the weight? By proceeding in such a ıer the result will be simply that illustrated in fig. 2.

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e foot note page 349.

it is meant that the pressure per unit of area of each parting would be the the first sheet should have been made absolutely rigid, and not "thorflexible," in order to justify this conclusion. The present writer commits to the opinion that if the sheets are flexible, and the pressure applied to a zone, the pressure per unit of area will rapidly diminish as the normal disrom the "limited zone" increases. See page 353.

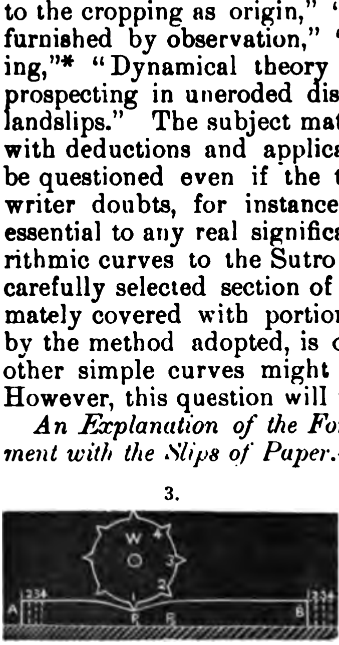
e pressure under the weight might be considered as approximately constant en as distributed approximately over the same area at each parting; but with the pressure under the blunt-edged ruler.

Mr. Becker's experiment in no sense, "forms a check upon the theory," since it deals with fundamentally different conditions. The fact is, the formation of this curve, in the experiment described, is due mainly to the *inequality* of the "pressure per unit of area" at the different partings.

An explanation of the formation of this curve is of little interest to the general reader; but an attempt at such will be added in order to bring out more clearly the inapplicability of the experiment to the real question at issue.

There are to be found in this Chapter IV many such headings: "Logarithmic distribution of energy," "Equation referred to the cropping as origin," "Spacing of contours," "Evidence furnished by observation," "Topography chiefly due to faulting,"* "Dynamical theory of sheets," "Rules applicable to prospecting in uneroded districts," "Application of theory to landslips." The subject matter under these headings is replete with deductions and applications, many of which might well be questioned even if the theory were correct. The present writer doubts, for instance, the existence of the conditions essential to any real significance in the application of the logarithmic curves to the Sutro Tunnel section. The fact that a carefully selected section of a natural surface may be approximately covered with portions of such curves, when calculated by the method adopted, is of little import. Doubtless many other simple curves might have proved equally serviceable. However, this question will not be discussed at present.

3.



An Explanation of the Formation of the Curve in the Experiment with the Slips of Paper.—A B (fig. 3) represents an elastic sheet resting upon an incompressible base, and W a toothed cylinder. There is frictional resistance to relative motion at the contact between sheet and base. If a pressure normal to the surface of the sheet is applied through W, tooth 1 will compress the sheet at point P_1, as shown, and extend it in length. If now the cylinder is rolled toward B until tooth 2 comes in contact with and compresses the sheet, the part P_1 B will be further elongated. Since the pressure, and consequently the frictional resistance to motion, at point P_1 of contact between sheet and base, is great as compared with the resistance at other points of the contact, the translation caused by this elongation will be almost wholly in the part P_1 B of the sheet. If the cylinder is rolled still further until tooth 1 leaves the surface of the sheet, the part A P_1 will have contracted. After teeth 2, 3, 4, etc. have done their

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* Referring to the Comstock country.

, the accumulated effect will be a material translation of heet in the direction of rolling.

is easy to see that a result the same in character will be ed if there is substituted for the toothed cylinder, a cylin- ithout teeth, the operation being continuous.

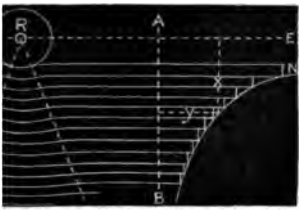
an edged ruler is applied and drawn from P_1 toward B the will depend upon the magnitude of the resistance which heet offers to the relative motion of the edge of the ruler. e edge be sharp and this resistance greater than the fric- l resistance between sheet and base, the result will be rela- rest of sheet and edge and slipping of the sheet upon the If, on the other hand, the edge be blunt and this resist- less than the frictional resistance between sheet and base, uler will slip on the surface of the sheet carrying the de- ion with it, and it is easily seen that the result will be the in character as in the case of the rolling cylinder.

4.

In rolling the cylinder from A to B the entire sheet will be compressed to thickness t_1 (see fig. 4), and the total translation of the sheet will be approximately equal to the full amount of extension which would result distributing uniformly from A toward B weights of suffi- magnitude to reduce the entire sheet to thickness t_1. explaining the formation of the curved surface the weight by Mr. Becker will be omitted, as it only serves to keep heets in contact. The cylinder will be substituted for the edged rubber. It will scarcely be doubted that these ges are admissible and will not affect the general character e curve formed. They are made in order to simplify the ments.

t fig. 5 represent an indefinite number of highly elastic flexible sheets of paper, having their edges originally in the surface A B normal to the upper surface M N. If cylinder R* is applied with pressure to the surface M N, this pressure will be transmitted normally to the curve of depression formed. The area of surface over which this pressure is distributed will rapidly increase—hence the diminution in thickness of a sheet, o compression, will decrease—with increase of the distance the upper surface M N. If now the cylinder is rolled to

5.



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t the length of the cylinder be greater than the width of the sheets, and e so placed that its axis is normal to the longer dimension of the sheets.

the right the amount of the translation of a sheet will decrease with increase of its distance from the upper surface M N, and thus the edges will form a curved surface.

If it is important to show approximately the character of the curve, an equation is easily deduced after making certain assumptions. Let it be assumed:

1st. That the diminution in thickness at a given point of the sheet, due to compression, is proportional to the applied normal force per unit of surface where applied.

2d. That the extension in the length of a sheet when uniformly loaded, is proportional to its diminution in thickness.

3d. That the pressure is uniformly distributed at any contact, over an area which is directly proportional to the distance x from the center of curvature of the contact surface between the cylinder and the upper sheet.

It will follow then, if c and C are constants and p represents the pressure per unit of area, that $p=\frac{c}{x}$ and since y is proportional to p, $y=\frac{C}{x}$.

The curve then will approximate in character an equilateral hyperbola, having A B and D E for asymptotes.

It is only claimed that the assumptions made are near enough to the truth to lead to a reasonably good conception of the character of the curve formed.

ART. XLIII.—*The Difference between Sea and Continental Climate with regard to Vegetation*; by Mr. BUYSMAN, of Flushing (Vlissingen), Holland.

THE difference between the vegetation of the sea and continental climates is, no doubt, best observed in the growth of the plants that are generally cultivated for different purposes in the temperate zone; as every climate has its own region or flora.

Whether the climate of a country is favorable to those plants or not is shown, in the first place, by their extension northward; and we shall first, therefore, endeavor to trace the northern limits of the most important plants, either cultivated in one country and growing wild in another, or cultivated everywhere.

To the first class most trees belong; to the second, annual or perennial plants. We begin with trees.

Pinus sylvestris L. Scotch Pine. Scotland, **59°**. Norway, 70° 20′. Kola, 69°. Petschora region, 67° 15′. Obi river, 66°. Turuchansk, 65°. The Werchojansk mountains, east of the Lena river (64°), are the eastern limits of this tree.[1]

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[1] Middendorff, Sibirische Reise, Bd. IV, Th. I, p. 556.

Betula odorata Bechst. (*alba* L. var.) Birch. Greenland, 61°, shrub. Iceland, 65°, shrub to 10 feet high. Britain, 59°. Norway, 70° 50′. Peninsula Kola, 69° 30′.[2] Peninsula Kanin 67°, to the Obi river 66°, and from the river Kolyma 68°, to the Peroshina Gulf 63°, and Kamtschatka; on this peninsula it is a large tree.

Quercus pedunculata Ehrh. (*Q. robur* L. var.), Common Oak. England, 58°. Norway, wild, to 62° 55′: cult. 65° 54′. Finland, coast, 61° 30′ (Björneborg). St. Petersburg, Taroslav, Perm, 58°.[3]

Larix Europæa DeC. (including *L. Sibirica* Ledeb and *L. Dahurica* Turcz), Common Larch. Norway, *Europæa* DeC. 66° 5′; *Dahurica* Turcz. 59° 55′; both cultivated. Onega river, White Sea, S. W. shore of Onega Lake, Mesen (Peninsula Kanin), 67°. Petschora river, 67° 30′. Ural mountains, 67° 15′. Kora river, 68°, northern limit in Europe. Yenisei river, 70°. Boganida river, 71° 15′. Chatanga river, 72° 30′, most northern limit of trees on the globe. Anabar, 71°. Oleneh and Lena, 72°. Yana, 71°. Yndigirha, 70° 45′. Kolyma, 69°. Anadyr, 65°. Between Ochotsk and Gishiga, 61°. Peninsula Sachalin, 49°. To Yeddo and the island Kunaschir, 43° 45′. On the shores of Kamtschatka the larch is nowhere to be found; in the valleys of this peninsula, however, protected from sea-winds, it is a very large tree.[4]

Pyrus Malus L., Apple. Shetland Isles, cult. Britain, 57°. Norway, cult., 65° 28′; wild, 63° 40′. Gulf of Bothnia, 63° 45′, cult. Finland, 63°, cult.; 60° wild. Northern shore of Onega Lake, cult. Narva, 59° 30′, wild. Twer, 56° 45′, wild. Nishny Novgorod, 56°, wild. Kasan, 56°, wild. Southwest of Orenburg, 50°. Kopal, Asia, 45°.

Fagus sylvatica L., Common Beech. Britain, 58°. Norway 59°, cult. 67° 56′. Sweden, 57°. Königsberg. Poland. S. W. Russia. Krim. Caucasus. Persia.

Castanea vesca Gærtn., Chestnut. South Britain. Germany (to the island of Rüyen). Austria. Caucasus.

Populus alba L., Abele Tree. Britain, 56°, wild and cult. Norway, cult., 67° 56′. Germany, wild and cult. Austria. Russia: Volhynia. Kiew. Charhow. Tambow. Kasan. Ufa. Altai Mountains.

Populus tremula L., Aspen. Britain, 59°. Norway, 70° 37′. Russia. Peninsula Kola, 69° 30′. Eastern shores of the White Sea, 66°. Yenisei, 66°. Kolyma river, 67° 30′.[5] Amur river.

Alnus incana W., Hoary-leaved Alder. Canada. Norway,

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[2] Ibid., p. 567.

[3] Ibid., p. 575.

[4] Middendorff, Sibirische Reise, Bd. IV, Th. I, p. 536.

[5] Middendorff, p. 573.

70° 30′. Kola, 69° 30′. Yenisei, 67°. Amur region. Petropaulovsk, on Kamtschatka.

Ulmus campestris L., Common Elm.' Britain, 57°. Norway, cult., 63° 26′. Russia: Ilmen Lake. South of Moscow. Riazan. South of Kasan and Ufa to the Ural mountains.

Tilia Europæa L. (inclusive of *parvifolia*, *grandiflora* and *intermedia*), Lime Tree. Britain, 57° (*parvifolia*). Norway, wild, 62° 9′; cult., 67° 56′. Petersburg. Kargopol. Ust Süssolsk, about 62°. Solikamsk. Ural mountains, about 58° 50′. Werchoturje.

Vinis vinifera L., Common Grape. Bretagne, 47° 30′. Liège, 50° 45′. Thuringia to Silesia, 51° 55′. South Galicia. South Russia, between about 48° and 49°. Astrachan. Buchara in Turkestan, 40°; here the vine is cultivated in the open fields.[6] Chiwa, 42°. China, 40°. California.

This plant cannot stand the extreme cold of the Asiatic continental winter climate, and requires a very warm or a very long summer (California); it cannot, therefore, be cultivated generally in Britain. The fact of its being cultivated with success in California is no doubt owing to the continual clear sky and then to the *direct solar warmth*; the *mean temperature* is here in summer *much lower* than in Europe in the same latitude.

Triticum vulgare Vill, var. *æstivum*, Summer Wheat. Britain. Norway, in the fields, 64° 40′; in gardens, 69° 28′. Finland, 65°.[7] Dwina river, 63°. Yakutsk. Western shores of North America, 55°. Fort Liard, 60° 5′ (N. W. territory of Canada).[8] Peace river, 56° 6′. Ontario. East Canada.

Hordeum vulgare L. (including *hexastichon*), Barley. Faröe Isles, 62° 15′, seldom ripe grains. Norway, 70°. Western shores of the White Sea, 67°. Ob river, 61°. Yakutsk, 62°. Udskvi Ostrog, near the Ochotsk Sea, 54° 30′. Kamtschatka (inland), 53° to 54°. N. W. American shore south of Sitka, 57°. Fort Norman, Mackenzie river, 65°.[9] East of Winnipeg, 50°. St. Lawrence Bay, 50°.

Avena sativa L., Oat. Scotland. Norway, 69° 28′. Finland, 69°. Asia: the same latitude as *Hordeum vulgare*. Yenisei, 61°. Yakutsk, 62°. Kamtschatka (inland). North America: the same latitude as *Hordeum vulgare*.

Secale cereale L., Common Rye. Britain. Norway, 69° 30′. Finland, 67°. Mesen river, 65° 45′. Petschora region, 65° 45′. Ural mountains, 57°. Obi river, 60°. Yenisei, 59° 30′. Yakutsk, 62°. Kamtschatka (inland). N. America, a little south of the latitude of the barley; eastern shores, 50°.

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[6] Grisebach die Vegetation der Erde, vol. i, p. 407.

[7] Middendorff, p. 709.

[8] Richardson, Searching Expedition through Rupert's Land, vol. ii, p. 267. Fort Liard is between 400 and 500 feet above the sea-level.

[9] Richardson, p. 269.

Solanum tuberosum L., Potato. Britain. Norway, 71° 7′. Russia, Pinega river, 65°. Turuchansk, 65°. Yakutsk. Shores of the Ochostk Sea. Kamtschatka. Kadjak Island. Sitka Island. Mackenzie river, 65°. Canada. Labrador, 58° 45′.[10] Greenland.

Zea Mays L., Indian Corn.—This plant requires also a very warm summer to ripen. In England it can be cultivated only as a green vegetable; on the western shores of Europe the cultivation is profitable only to the 46th degree N. L., while in the valley of the Rhine it reaches to 49°. In Northern Germany the grain usually does not ripen. In North America, however, it is cultivated with profitable returns up to 51° N. L.[11] The period of vegetation varies there between seven and three months. Cultivation of the varieties maturing in a shorter period has been tried in Europe but without success; they were transformed after a few generations into the common corn. There must exist peculiar relations between the American climate and the vegetation of this plant.

Thus we see that of the plants just named, the Larch, the Pine, the Birch and the Aspen go into Siberia, with its excessive continental climate, farthest to the north; yet many of the cultivated plants mentioned above, and almost all those of the temperate zone, are either cultivated or grow wild in the sea climate of Norway to very high latitudes.

On the northwest shores of America the Pine attains considerable size (Sitka) in a climate with continual precipitation, but the same size is to some extent observed on the Rocky Mountains (eastern slope), where the climate is wholly different.

In British Columbia the climate is continental and very cold in winter, yet the same gigantic trees are here to be found as on the coast; precipitation takes place in spring, but the amount is very great.

In California, with the largest coniferous trees of the world, (*Wellingtonia gigantea*), rain falls chiefly in winter (November to April); the other months are dry. The cause is known: the polar stream coming from the northwest reaches the Californian coast under about 45° N..; the water being in summer much colder than the land and the winds in this season mostly northwest, no precipitation can take place. This is the cause also of there being very little difference in temperature between summer and winter;[12] but climatical causes will not alone explain the gigantic vegetation of the west and northwest shores of North America. In Norway or Ireland, both having very wet climates, such enormous trees are nowhere to be found. It is a peculiarity of the Pacific coast vegetation, the cause of which is unknown.

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[10] Petermann, Geogr. Mittheilungen, 1859, p. 124.

[11] Richardson, vol. ii, p. 267.

[12] San Francisco, winter 46°, summer 53°, year 51°.

In the southern parts of the Amur region in Asia, there is in summer a luxuriant vegetation; the annual precipitation amounts to 27·56 inches (about the same amount as in Germany), and the plants much resemble those of Central Europe,[13] and this notwithstanding a winter temperature much lower than is observed in the most northern parts of Lapland; but the summer is here much warmer than in Europe under the same latitude, and *precipitation takes place only in summer.*

In the interior of Siberia the vegetation consists chiefly of coniferous trees; thus the luxurious growth in the region just named must be caused by the influence of the sea climate, as Middendorf suggests,[14] though there is a mountain chain on the east coast.

The extensive forests of Russia and Siberia prove that an extreme continental climate is resisted by some coniferous and other trees; but it is evident that in general a sea climate with mild winters, and thus a long period of vegetation, suits them best.[15]

As we have seen, the northern limit of the cultivation of corn reaches to a much higher latitude over the continent than near the seashore. On the northwest coast of North America the Island of Sitka (57° N. L.) and Radjah are on the extreme limit. On the Faroe Islands barley is cultivated, but corn seldom ripens;[16] the cause is absence of sunlight on account of the continual cloudy sky, storms and precipitation causing low temperature in summer (mean temperature at Thorshaven in July, 55°); for corn wants a sunny climate and the direct influence of the sun's rays. This explains why it can be cultivated within the polar circle (Norway) where the sun in the summer season remains constantly above the horizon.

In North America, on the shores of Hudson's Bay, the tree limit goes down to 59°, the corn limit to 50° (Ontario). On the shores of the Ochotsk Sea corn cannot be cultivated at all, even on the south coast under 50°. In Greenland also the cultivation of corn is impossible. The causes are the same as stated above—the sea winds, wet climate and fog in summer; that is, want of sunlight.

Of all cultivated vegetables *Raphanus sativus* L. et var. (Radish), *Brassica Rapa* L. et var. (Turnip) and *Brassica Napus*

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[13] Kittlitz. Vierundzwanzig Vegetationsansichten von Küstenländern und Inseln des Stillen Ozeans, p. 53.

[14] Middendorff, p. 763.

[15] The stems of all the Siberian trees are slender compared with those of Europe, even when they are centuries old. Middendorff, p. 632.

[16] Martins, Sur la vegetation de l'Archinel des Féroé.

L. et var. (Rape) grow as far north as there are settlements. In Norway beyond 70° N. L.; in Siberia to the Polar Circle; on the N.W. coast of America to 64° 45′ (Nulato) and Redout St. Michael (63° 30′); in the interior to 67° (Fort Good Hope).[17] In Greenland, Rapes, Turnips, Cabbage and Salad are cultivated under 70° L. (Island Disko).

The potato follows the above named plants in their distribution to the north and belongs also to sea climate species. On its northern limit, however, in Siberia as well as in N. America, it reaches only the size of a walnut.[18] In Greenland, only the most careful treatment can produce eatable potatoes. The plant never blossoms there.[19]

Comparing the vegetation of the extreme continental climate with that of the extreme sea-climate on the globe, the continental has the advantage. The South Shetland Islands under 60° -63° S., are the most southern limit of phanerogamous plants (only a grass—*Aira antarctica* Forst—is found there); and on Cockburn Island, 64° S., the last trace of vegetation is found (cryptogamous plants). In this latitude north there is in Siberia a forest of very high coniferous trees. In the antarctic regions there are several causes why vegetation ceases at so low a latitude, but these are all consequences of the chief cause, viz: the fact that the whole southern hemisphere, with the exception of relatively small spaces, is covered with water; a continual very low barometer and severe storms,[20] combined with a very low summer temperature,[21] banish all vegetation.

The extreme continental climate has also its disadvantages, but chiefly with relation to the cultivation of corn. In the first place, corn is very often destroyed by night frosts, which make the harvest uncertain.

The constantly frozen ground is the chief cause why corn cannot be cultivated in Siberia beyond 62° (Yakutsk). The temperature of the soil in which the roots vegetate varies between 36° and 41°. Thus, notwithstanding the mean temperature of June at Yakutsk is 55°, and that of July 62°,[22] the vegetation is relatively slow,[23] though its period (10 to 12 weeks) is the same as observed in Central Europe. The same period is observed in North America, under 63° (Fort Simpson)[24] of the barley. (Wheat does not come to maturity there.) But a harvest of thirty to forty times the quantity that was sown alternates in this climate with years of no harvest at all."[25]

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[17] Richardson. vol. i, p. 214.

[18] Middendorff, p. 700.

[19] Etzel. Grönland geogr. und statistisch beschrieben. Stuttgart, 1860, p. 282.

[20] Lowest reading of the barometer by the United States Exploring Expedition under Wilkes on lat. 65° 15′, 27·50. See Narrative of the Expedition, London, 1852. vol. ii, p. 281.

[21] Under lat. 64° 5′ mean temp. of January, 1843, 31°; under 62°–66°, in February, 31°. See Ross, Voyage in the Southern and Antarctic Regions, vol. ii, p. 352–360.

[22] Middendorff, p. 772.

[23] Middendorff, p. 718.

[24] Richardson, vol. i, p. 165.

As is well known, the native plants withstand the lowest temperatures of the Siberian winter.

Returning to Europe we have seen that even the climate of the northern parts of the British Isles is not suited for many vegetables and other cultivated plants.

It is Germany which has a climate adapted to almost all the plants of the temperate zone and to those commonly cultivated. We see the vine in this country ascend farthest to the north, while corn and all vegetables ripen their seeds perfectly. The climate is clearly that best suited for the vegetation of this latitude.

Now, if we compare the mean temperature of July in Germany with the mean for the latitude (for 50° N.—62°) calculated by Dove, we find that even in this country the summer temperature is, in general, *only a few degrees above the calculated.* Germany is crossed in July by the isotherm of 68°, and Britain by that of 59°; but the difference in vegetation is not caused by a difference in mean temperature of nine degrees, but by the difference in the *days of sunshine.*

Thus we come to the conclusion that a mixed climate with relatively mild winters (the anomaly of temperature for January is for Germany about +9° on the 50th degree of latitude) and *warm sunny* summers is the condition best suited for the vegetation of the temperate zone.

Flushing, June, 1884.

ART. XLIV.—*Chemical Affinity*; by JOHN W. LANGLEY, Ann Arbor, Michigan.

[Address before Section "C" of the American Association for the Advancement of Science, Philadelphia, 1884.]

IN reviewing the history of each living being and of every intellectual conception we are at once made aware of a law of growth, the most general and fundamental possible, namely, that of development, or progression along what often seems to be a predetermined line whose constraining influence is so powerful that it is only by following it that the organism can escape destruction.

Development, while it may be continuous, both for the individual and for the race when broadly looked at over large intervals of time, is, on the other hand, a process which in its details is constantly interrupted both by alterations of directions and by arrests of action which may even go so far as to cause retrograde metamorphoses.

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[25] Middendorff, p. 720.

A plant may readily grow unsymmetrically if shaded on one
de; but that error of form will be largely corrected when it
again bathed with light which comes from all directions.
his partial arrest may even arise from the plant itself, as
hen the excessive growth of the vine in forming new wood
ps the energy which should go to the formation of fruit, and
e grapes, which alone make the plant valuable to man, never
ach that fullness and flavor which should recompense the
il of the husbandman.

All of us here are constituent intellectual atoms in a great
leal organism called Chemistry. We know the long and hon-
rable history of our science, we know too its wonderful
rogress in the past fifty years; we perceive how from the
ngle stem of alchemy it has thrown out branches in all
irections, Mineral, Organic, Analytical, Synthetic, Agricul-
ral, Physiological, Biological Chemistries; but has it fur-
ished a corresponding number of great far-reaching laws?
as it been equally prolific of grand hypotheses which have
ood the test of time?

Will you pardon me if I venture to apply the analogy of the
ant, and to ask whether our development has been symmet-
cal, whether some struggling bud put forth in our youth has
t been starved and shaded by the abundant leafage of our
anches, and whether in the rapid accumulation of facts from
at great diffused solution of them called Nature, while we may
ve greatly increased our quantities of chlorophyl and cellulose
e may have been equally successful in elaborating well-rounded
neralizations which fill the intellectual taste with a sense of
light, and which stand forth as the declared fruit of our toil.

Such a fruit bud our science put forth in its alchemical
age under the name of affinity. During the early part of the
esent century the idea received considerable expansion and
owed at one time a vitality comparable with the condition of
e doctrine of the conservation of energy prior to the year 1850.

Having reached this stage the development of a theory of
finity seems to have been arrested and soon it is seen occu-
ying a position of constantly decreasing interest to chemists.
he proof of this statement is easily found by comparing such
orks as Daniel's Introduction to Chemical Philosophy,
hompson's History of Chemistry and Daubeny's Atomic
heory, published in 1830 and '31, or the works of Berzelius,
ith any recent manual of inorganic chemistry. In the older
oks the amount of space given to the treatment of chemical
finity is relatively large, while in the treatises of to-day it is
many cases hardly even mentioned.

In the article Chemistry, in the new Encyclopædia Britan-
ca, covering 120 pages, there is not a single paragraph referred

to the title of affinity, and less than half a page devoted to it indirectly. In Watt's Dictionary of Chemistry, including the supplements, out of a total of 9,665 pages only 62 are devoted to affinity where it appears under the head of Chemical Action. In Wurtz's Dictionnaire de Chimie the treatment of affinity under the several heads of Chaleur, Electro Chimie, Affinité, Atomicité, etc., is relatively fuller, but still the proportion is quite small; and in that excellent manual, Remsen's Theoretical Chemistry, the second edition of which was published last year, the word affinity does not even occur in the index. The causes of this almost complete abandonment of a word and an hypothesis at one time considered of fundamental importance can best be traced by reviewing briefly the history of that part of speculative chemistry which is related to the doctrine in question, and it will become apparent that it is the word only which is becoming obsolete. I will therefore venture to ask your attention to what I am only too well aware is but a sketch of the development of theories concerning the nature and fundamental cause, or causes, of chemical phenomena.

I. THE CONCEPTION OF AFFINITY.

The earliest appearance of the idea, which has since been named chemical affinity, is found in the writings of Hippocrates in the fifth century B. C., where the opinion is expressed that when two bodies unite to form a compound, a certain common principle must indwell in them, for it is laid down as a fundamental postulate that "Like unites only with like," hence the two bodies must possess some common principle, or have a bond of kinship between them.[1] This conception prevailed with more or less clearness for several centuries, but it is not till the year 1698 that we find the word *Affinitas* employed and defined. It first occurs in the writings of the alchemist Barchusen,[2] and the conceptions of Hippocrates were still the ruling ones. Thus Barchusen explains the impossibility of completely isolating the four elements by saying that they have for each other a strong affinity which causes one to mingle with another, and which cause is derived from a principle common to them all.

Boerhaave, the celebrated physician of Leyden, in his elements of chemistry which appeared about 1732, was the first to extend the meaning of the term *Affinitas* or *Verwandtschaft*, since he says, "the effort also of like substances to unite is due to the working of the same force;"[3] and elsewhere, in explaining the cause of solution, he says, "In this last case" (that of the action of aqua regia on gold) "why do not the particles of gold which are nineteen times heavier than the particles of aqua regia collect together in the bottom of the vessel. Do you not see clearly that there is between each particle of gold and each particle of aqua regia a force in virtue of which they seek each other out, unite and retain each other."[4] We also notice in Boerhaave's writings a tendency to regard combination as due to the attraction of opposite, rather than to the union of similar qualities; for he compares the action of an acid upon iron to a marriage, and says that the combination comes rather from love than hate.

Two of Boerhaave's successors, St. F. Geoffroy and Torbern Bergmann, appear to be the authors of a new conception which was subsequently known under the name of Elective Affinity. Geoffroy attempts to indicate the order of chemical actions, or as we should now call it, the relative intensity of combining power, by arranging several bases in the order in which they displace each other. Thus one of his tables was the following:

Vitriolic Acid.[5]

Sel Alkali, fixed.
Sel Alkali, volatile.
Earths.
Iron.
Copper.
Silver.

It was soon discovered, however, that an order of bases which might be correct for one acid would be incorrect for another, and that a given substance would take different positions in the two.

The following, which is a portion of one of Bergmann's lists published in 1783, will show the fact:[6]

Gaseous Acid. (*Carbonic.*)	Acid of Sugar. (*Oxalic.*)
Pure heavy earth.	Lime.
Pure lime.	Heavy earth.
Fixed vegetable alkali.	Magnesia.
Fixed mineral alkali.	Fixed vegetable alkali.
Magnesia, etc.	Fixed mineral alkali, etc.

The reversal of the order of attractions was explained by assuming the existence of preferences or special attractions between acids and certain bases, and was known under the name Elective Affinity, a term which has remained in chemical literature till quite recent times, and indeed, was very generally used within the recollection of most of us here present.

The chemist, Glauber, 1689, was one of the first to recognize this fact of differential attractions. He teaches[7] that "potash, lime and zinc oxide, with application of heat, drive out ammonia from sal-ammoniac because the zinc, as also potash and lime, is of such a nature that it has a great community of interest with all acids, loves them and is also loved by them; accordingly when warmed the acid of the salt (muriatic) attaches itself to it, combines with it so that the sal volatile is set free and is distilled to a subtle spirit."

The next advance in the direction of precision was made by Wenzel,[8] who, in a work entitled *Lehre von den Verwandschaften*, published in Dresden in 1777, showed that when two neutral salts act upon each other by double decomposition, the new salts formed are also neutral and thus prove chemical unions to be governed by some general law which determines how much of one acid must be taken to displace another. Although Wenzel's work attracted but little attention at the time, we can now see on looking back that it marked a very important discovery, for he must be regarded as the first man who apprehended with any distinctness that fundamental law of chemistry, definiteness of action, which was subsequently enunciated and is familiar to us to-day under the name of the "law of definite proportions." The final result of Wenzel's discovery was the establishment of the law of equivalent proportions through the labors of Richter, Thompson, Wollaston, Berzelius and others, and from equivalent proportions sprang the Daltonian hypothesis of atoms which has developed into the all but universally accepted Atomic Theory of the present day.

The atomic theory, however, is not necessarily coterminous with hypotheses about affinity, and indeed in many respects it is independent of them; the development of its history is therefore foreign to the purposes of this paper, but if we turn back to the period which immediately follows Wenzel's discovery, which was that of the re-birth of the atomistic theory of the Greeks under Dalton's parentage, we see that it emerged from opposing views about the nature of affinity, and at this point, therefore, the two speculations have a common history. The opening of the present century witnessed an active controversy between the advocates of the new, or equivalent and atomistic school, against the partisans of the older philosophy. Prominent among the latter stands Berthollet who was a consistent and earnest opponent of the new doctrines. In his well known work, *Essai de Statique Chimique*, published in 1803, he maintains the proposition that all unions are caused by the joint action of two forces which are opposed to each other—cohesion and elasticity. He denies entirely that the union by equivalent or definite proportions is a fact. In opposition he brings forth his celebrated theory of mass, according to which combination occurs under the influence of cohesion and in proportion to the masses of the reacting bodies, being directly proportional to these two forces and inversely proportional to the elasticity or volatility. Berthollet considers that there is no distinction of kind between chemical union and mixture except that in the first the action of cohesion is more apparent. He says,[9] "The force of cohesion is often a cause which determines combinations. Whenever there is produced some solid substance, whether by a separation or by a combination, we must look to the reciprocal action (cohesion) of the parts which acquire solidity for the cause which produces it, although it did not manifest itself previously. Alkalinity and acidity have no influence on the reciprocal action of salts which are in the neutral state, but all the phenomena which they produce must depend on the properties which emanate from the reciprocal action of their integral parts. In the mixture of liquid substances (neutral) those combinations which ought to act with a force of cohesion capable of separating them ought to be formed and separated in fact."

The position assumed by Berthollet was, of course, finally overthrown by the improvements in methods of analysis on the one hand, and by the Daltonian theory of atoms on the other; but it is a noteworthy fact that it is only as a complete and universal explanation of chemical action that Berthollet's theory fails. In many respects his position still holds good and his views on the influence of mass are being now revived and partially confirmed by researches made within the present decade.

The progress made in the allied science of physics now begins to react on chemical studies and we find the subject of electricity, which was opened by Galvani and Volta, taken up and pursued by men who are eminent both as electricians and as chemists. Davy, in 1807, and later more fully in 1826,[9] introduced the electrical theory of the nature of chemical affinity and stated that "chemical and electrical attractions depend upon the same cause, acting in one case on particles, in the other on masses of matter." His contemporaries and successors, Oerstedt, Grotthus, Ampère, Becquerel, Berzelius and Faraday amplified and extended the electrochemical theory. Grotthus contributed his well-known hypothesis of liquid polarization. Ampère considered that each atom is surrounded by a special atmosphere of electricity, positive or negative, and that combination of atoms occurs by the neutralization of the opposing atmospheres. Berzelius held that the atoms have poles. He says,[11] "Affinity is only the effect of the electric polarity of the particles; electricity is the primary cause of their chemical action; it is the source of the light and heat disengaged during combination;" and finally Faraday's immense contribution to electro-chemistry is too well known to need any further mention here.

Notwithstanding this array of great names and the stores of experimental knowledge contributed by their owners, electrical hypotheses do not seem to have added much that is valuable to the theory of chemical action except in one respect, which, however, is a fact of the utmost importance, namely, that whenever combination or decomposition takes place the corresponding decrease or increase in the value of the affinity involved is revealed as a definite and measurable amount of energy, which may be either electrical, thermal or mechanical. We have by this theorem a mode of measuring affinity quantitatively; but electrical theories do not establish the *nature* of this force beyond dispute, and this is shown by the fact that the English school of electricians, under the leadership of Sir William Thomson, have for some years been divided in opinion as to the sources of the current developed by the galvanic battery, between the old contact theory of Volta and the chemical theories of Davy and Faraday. While the electro-chemical theory was being developed the founders of the atomic theory were not idle, and in that wonderfully fruitful decade which witnessed the enunciation of Dalton's views we find also the nucleus of an idea which has an important bearing on the nature of affinity.

In 1811 Avogadro[13] formulated that law which is now regarded as the strongest bolt in the framework of the atomic theory; but in stating his conclusions in regard to the number of "elementary molecules" in equal volumes of gases he necessarily introduced the conception of what is now the fundamental distinction between atoms and molecules, and its later development into our belief in the two orders of combination, atomic and molecular.

This theorem, of the utmost importance to the atomists, cannot, however, be considered as a material contribution to the theory of affinity, because the actions of this force are experimentally evident and are, therefore, not dependent for their verification on the molecular theory; but the form which this idea subsequently took in the mind of Brodie was, on the contrary, of the highest importance for it is essentially a new conception.

In his paper entitled, "On the state of the elements at the moment of chemical change,"[14] this chemist regards the molecules of elementary bodies as composed of atoms. The difference between the action of an element when free and when combined is due chiefly to the fact that when free the element is combined with itself in the form of an integral molecule. He says, "The general object of the paper may be considered as to prove that, at the moment of chemical change, the same chemical relation exists between the particles of which certain elements consist, as between the particles of compound substances under similar circumstances, on which relation the phenomena of combination and decomposition depend; that, in short (to use common language), the particles of the element have a chemical affinity for each other." It is true that Brodie's terminology is drawn both from the atomic and from the electro-chemical theories, for he uses the expression, "Polar relation" instead of chemical affinity, but his idea s actually independent of these hypotheses; for what he really shows is that an element may combine with itself. What is new and original in his conception is that affinity can be exerted by one portion of an element on another portion of the same element, and hence there is no distinction of kind between the attraction of a body for other substances and its attraction for itself. This must certainly be regarded as an mportant extension of former ideas about combination. How fertile it is we see in its application to the structural formulæ of the organic chemistry of to-day.

There remain three discoveries which have brought modifications into the older conception of affinity. They are: 1st, The influence of structure or position; 2d, The subject of valence; 3d, The periodic law applied to the elements. Two of the discoveries are, compared with the long history of the science behind them, almost affairs of yesterday. All of them are now subjects of debate and controversy, and they have taken their present form rather from the nearly simultaneous abors of many chemists than from the projecting force of a single brain.

To trace the history of these doctrines would be difficult; to apportion justly the share of merit belonging to each contributor would be impossible, for we are now in the midst of the struggle, conflict and change which mark the progress of every living idea, in the same way that they are necessary accompaniments of every vital organism. It is too soon, therefore, for any one to know what part is destined to remain and what to perish.

The germs of the idea, that the position of an element in a compound influenced profoundly the ordinary behavior of that element, originated on the one hand in the theory of radicals which owes its origin to De Morveau, 1787, Berzelius, 1817, and especially Liebig, 1832; and on the other, in Dumas's discovery n 1834 that chlorine could be substituted for hydrogen. Although the term radical as now used means something quite different from Liebig's radical, it is certain that our present conception of acids, as bodies which can be divided into hydrogen and an acid radical, is justified only from the discoveries of those chemists. It is unquestionably true that in acetic acid $HC_2H_3O_2$ we have hydrogen in two distinct positions, or, f I may be allowed the expression, two kinds of hydrogen: one, the basic, replaceable by a metal; the other, that within the acid radical, not displaceable by a metal, but easily removable by chlorine; and further, the substituted chlorine will have lost its familiar characteristics; for example, it will no onger precipitate silver, but will, on the contrary, assume a part of the duty previously borne by the hydrogen in the new acid, chloracetic, thus formed. Evidently we have here shown to us a new property of elements brought out by the facts of substitution, and shown with equal distinctness by the facts of isomerism. It does not arise from the particular symbol selected, or from the expressions atom and molecule. If the atomic theory were abandoned to-morrow the above indicated experimental differentiation of hydrogen into two states or kinds would receive our rational indorsement though all our vast wealth of atomic expression had perished.

The invention of the terms valence, or "atomicity," is generally credited to Adolph Wurtz, but the idea behind the names grew up so gradually from the theory of types, from the study of radicals, and from the controversy on the cause of etherification, also from the labors of Laurent, Gerhardt and Sterry Hunt, that it is hardly prudent to assign any specified year as the exact date of its origin. The "periodic law" is customarily associated with the name of Mendelejeff,[14] and modifications in the form of the law with that of Lothar Meyer.[15]

There is also an English chemist, J. Newlands,[16] who claims to be the originator of the discovery; his speculations being published in 1864 while Mendelejeff's did not appear till 1869. Both of these conceptions, valence and periodic law, are immediate outgrowths of the atomic theory. The values assigned under them, and even their very form, depend absolutely on our choice of the numbers expressing atomic weight; for instance, the distinction between monad chlorine and dyad oxygen wholly disappears when the old symbols, HO for water, and HCl for hydrochloric acid, are employed. It is an open question whether valence has any proper connection with affinity. Many chemists make an absolute distinction between them; moreover the doctrine of atomicity is so preëminently a living issue of to-day that any discussion of it here would be out of place.

Finally, I will close this review with a condensed statement of the principal theories of affinity, taken from Watts' Dictionary:[17]

1.—"*Chemical combinations are produced by universal attractions.*"

The most noted adherents of this view are, Newton, who considered affinity as identical with the force of gravitation, and Berthollet, who held it to be the same as cohesion.

2.—"*Chemical combinations are produced by a peculiar power called affinity, distinct from universal attraction.*"

Under this head we may place the alchemists and the believers in elective affinity.

3.—"*The union of heterogeneous atoms is the result of electrical attractions.*"

This includes Davy, Ampère, Berzelius and perhaps Faraday.

4.—"*Chemical action results from a constant motion among the ultimate particles of bodies, this same movement likewise giving rise to the phenomena of heat, light and electricity.*"

This is Williamson's theory of incessant atomic interchange between all molecules in solution.[18] The same hypothesis has also been sustained by Kekulé and Michaelis.

The above closes this very imperfect sketch of the growth of the *conception* of affinity, but it ignores the important dynamic problem connected with it. Let us turn our attention to the questions of force and energy which form so important a part in the history of every chemical change.

II. QUANTITATIVE MEASUREMENTS OF AFFINITY.

The earliest attempts to measure the strength of affinity appear to be those of Geoffrey and Bergmann by arranging the several bases in the order in which they combined with a given acid, or as we should now say, in the order in which they replaced each other. Illustrations of these tables have already been given and it was apparent at a glance that the elective affinity so measured could at best be only related to some one reaction arbitrarily chosen, and that the strength of attraction, as shown by the order in which the bases were arranged, was variable and depended on the nature of the acid selected.

These tables were amplified and improved by Young and Richter, the latter of whom, in his work published in 1792,[19] gave numerical values for what he calls the capacities of saturation which belong to the several acids and bases. These numbers however do not express the strength of chemical action in terms of force, but rather the weights of the several bases which combine with an acid; they are therefore primitive determinations of equivalent weights, and hence they belong more to the history of the atomic theory than to that of affinity.

In referring to the law of Avogadro I said that while he introduced the distinction between the two kinds of "elementary particles" from which has since come our existing belief in the two kinds of union, atomic and molecular, still his proposition could not be considered an important contribution to the theory of affinity while it rests for its validity on the language of the atomic theory. The proof of this conclusion will be evident when we consider that the same discrimination between the two kinds of chemical union was very clearly foreshadowed from speculations concerning the value of chemical attractions before Dalton's hypothesis was given to the world.

An English chemist, William Higgins, Professor of Chemistry to the Dublin Society, published in 1789[30] a work in which the composition of several bodies is attributed to the union of "ultimate particles," sulphurous acid being formed of one particle of sulphur and one of oxygen, "Nitrous air" of two particles of dephlogisticated air and one of phlogisticated air, etc. He assumes that the attractions between iron and phlogisticated air (oxygen) may be expressed by a certain number, seven, for example; that the force between sulphur and phlogisticated air will then be represented by six and seven-eighths; finally that the iron will also attract the sulphur and the oxygen not already combined with itself by the feebler force of two. Now under these conditions the iron cannot break up the sulphur compound nor the sulphur the iron compound, but both the phlogisticated iron and sulphur will be united into a compound system by this residual force of two existing between the groups. This is exactly what would be represented by the equivalent symbol for ferrous sulphate, FeO, SO_3, where the oxide of iron FeO, and the sulphuric acid SO_3, were each regarded as entire or binary compounds united to form the ternary body, FeO, SO_3.

Shortly after these attempts of Higgins, we find, in the opening years of the present century, three general methods indicated for the study of the force of affinity. Instead of being successively taken up and abandoned, like all preceding speculations, they have remained steadily in use during the eighty years which have intervened, and they are to-day still the most promising means at our disposal. These three methods may be called the thermal, the electrical and the method of time or speed. It will be convenient to consider each one separately.

The thermal method was first indicated by Lavoisier in a memoir, a portion of which will bear quotation. He says:[31] "The equilibrium between the heat which tends to separate the molecules, and their reciprocal affinities which tend to reunite them, can furnish a very precise means of comparing affinities with each other; if we mix, for example, at any temperature below zero (Centigrade) an acid with ice, it (the acid) will melt it until it is so enfeebled that its attractive force on the molecules of the ice becomes equal to the force which makes these molecules adhere to each other, and which is so much the greater as the cold is more considerable; thus the degree of concentration at which the acid will cease to dissolve the ice will be so much the greater as the temperature of the mixture is lowered below zero, and we can refer to the degrees of the thermometer the affinities of acids for water according to various degrees of concentration."

This method, indicated by Lavoisier, would seem to be a promising one but it has never been followed, so far as I know, by anybody unless it may be by Guthrie in his investigation of Cryohydrates.[22]

The study of the heat evolved when various elements unite with each other and when acids combine with bases has been pursued by many observers. The literature of the subject is already large and it now constitutes a very important branch of our science under the title of Thermo-chemistry. Early pioneers in this field were, Thomas Andrews 1844,[23] Thomas Woods 1851,[24] Favre and Silberman 1853,[25] J. Thomsen 1853,[26] M. Berthelot 1864 and Alex. Naumann.[27]

The work of Thomsen, entitled "Thermochemische Untersuchungen," in three volumes, published at Leipsic, in 1882, and that of Berthelot, "Essai de Mechanique Chemique," in two volumes, Paris, 1879, are models of painstaking and exhaustive research. By the labors, chiefly of these two men, we now know the thermal values corresponding to many thousands of chemical reactions. We have learned that the energies of a reaction which can be brought about in two methods, either in the dry way or by solution, differ in the two cases; that salts in solution are in a partial state of decomposition; that the attraction of a polybasic acid radical is not the same for the successive portions of base added, and that the behavior of a monobasic acid in solution differs essentially from that of a dibasic or tribasic acid.

The most important generalization to be drawn from thermochemical phenomena is that the work of chemical combination, or the total energy involved in any reaction is very largely influenced by the surrounding conditions of temperature, pressure and volume; and the conclusion they force upon us in regard to the nature of affinity is most important, namely, that this force in accomplishing work is dependent, like all other forces, on the conditions exterior to the reacting system which limit the possible amount of change. Affinity is therefore at last definitely removed from the category of those mystical agents so often invoked by our predecessors in a less critical age as belonging to causes which had no correlation with the general forces of nature.

Under the title *Dissociation*, St. Claire Deville gave to the chemical world in 1857[28] a new and fruitful method of investigating the nature of compounds. By determining the temperature at which bodies break up or are dissociated he was able to perform a purely analytical operation on them not complicated by the introduction of any extraneous form of matter, and since the gradual increase of temperature can be closely dinated and watched, we have in the process of dissociation f *an almost* ideal analysis.

The laws developed by Deville and his successors in this field show us, that after the point is reached at which decomposition commences, the further breaking up is determined by the pressure of the evolved products of the reaction, so that the permanence of the body depends on the magnitude of two variables, pressure and temperature, either of which may be varied at will through a wide range. Deville thus gives us a fundamentally new mental tool with which to attack the problem of affinity by showing the close parallelism between chemical decomposition and the ordinary evaporation of a liquid at its point of maximum tension.

The electrical method of dissecting chemical forces has been followed less actively than the thermal one. Besides the well-known experimental contributions of Davy, Becquerel and Faraday, many other more recent workers have studied the chemical changes of the battery and the electrolytic cell. Among these may be mentioned Joule's researches on the heat absorbed during electrolysis, and especially the work of C. R. Adler Wright on the "Determination of Affinity as Electromotive force" in the Philosophical Magazine for 1880, 1881 and 1882.

The general outcome of these researches is that the products of electrolysis are so numerous and so varied by the results of secondary actions that it is very doubtful whether the electromotive force measured is that due solely to the union of those atoms which are indicated by the principal equation of the reaction. The method of time, or speed of chemical reactions, has a history as old as that of its two associates, but the story is much less eventful, for very little work has been done in this field. Wenzel held that the affinity of metals for a common solvent, such as nitric acid, was inversely as the time necessary to dissolve them; the attacked surfaces being equal and invariable. He experimented on small cylinders covered with wax except on one of their bases."[29]

The most notable work in this field has been done by Gladstone and Tribe[30] by ascertaining the rate at which a metallic plate could precipitate another metal from a solution; by Berthelot, Menschutkin and others who have studied the time necessary for etherification. The rate of inversion of cane sugar has been investigated by Urech, and in this country by R. B. Warder. The above are only three out of many subjects which have been studied in regard to their time rate. An index to the literature of this subject has been made by one of the members of this section, Professor R. B. Warder, and may be found in the proceedings of last year."[31]

To these general methods for studying the problem of chemical dynamics should be added the investigation of the action of mass by Gladstone, in his well-known color work on the sulphocyanides of iron;[32] the chemical action of light by the late J. W. Draper,[33] in this country, and Professor H. E. Roscoe[34] in England, as well as Becquerel[35] in France, pioneers who have since been followed by a host of students of scientific photography.

In the review just given no attempt has been made to do more than glance at the important contributions to the theory and methods of measuring affinity. Many names have been passed by and much work has been necessarily ignored owing to the limits of time and space which surround the writer of an address like this; but notwithstanding the presence of those limits, and my consciousness of how greatly your patience has been drawn upon, I will venture to add a few words on one other phase of the subject, and that is *The Existing Problem.*

LIST OF AUTHORITIES QUOTED.

1. H. Debus: Ann. Ch. Pharm., lxxxv, 103.
2. Barchusen: Pyrosophia, 1698.
3. H. Debus: loc. cit.
4. Wurtz: Dict. Chim., article Affinité.
5. Idem.
6. Torbern Bergman: De Attractionibus Electivis, 1775; also in the 3d volume of his Opuscula Torberini Bergman, Phys. et Chemica, 1783.
7. H. Debus: loc. cit.
8. Charles Daubeny: Introduction to the Atomic Theory. 2d ed., p. 55.
9. C. L. Berthollet: Essai de Statique Chimique, 1803.
10. Sir H. Davy: Phil. Trans., 1807; ditto 1826.
11. Wurtz Dict: loc. cit.
12. Amadeo Avogadro: Journal de Physique, lxxiii, p. 58.
13. B. C. Brodie: Quar. Jour. Chem. Soc., iv, 194.
14. D. Mendelejeff: Zeitschrift für Chemie, 1869, 405; and Annalen der Chemie, 8 suppl., 133.
15. Lothar Meyer: Ann. der Chem., 7 suppl., 356.
16. J. Newlands: Chem. News, x, 59–94.
17. Watt's Dict.: vol. i, p. 865.
18. A. W. Williamson: A Theory of Etherification; Quar. Jour. Chem. Soc., iv, 106.
19. J. B. Richter: Anfangsgrunde der Stochiometrie, Breslau, 1792.
20. William Higgins: A Comparative view of the Phlogistic and Antiphlogistic Theories, 1789.
21. Wurtz Dict.: Art. Affinité, p. 72.
22. F. Guthrie: Phil. Mag. [4] xlix, 1–20. *The first of several papers by him on Cryohydrates.*
23. Thos. Andrews: Phil. Trans., 1844; also Phil. Mag., xxxii, 392, followed by a series of papers on the same subject.
24. Thos. Wood: On the heat of Chemical Combination. The first of the series is in Phil. Mag. [4] ii, 268.
25. Favre and Silbermann: Ann. Ch. Phys. [3] xxxiv, 385, and in succeeding volumes.
26. J. Thomsen: Pogg. Ann., lxxxviii, 349, and in following volumes.
27. Alex. Naumann: Lehr- und Handbuch der Thermochemie. 1882.
28. H. St. Claire Deville: Compt. rend., xlv, 857; also in the Leçons de Chimie of the Paris Chemical Society, on Dissociation, 1864, and on Affinity, 1867.
29. Wurtz Dict.: loc. cit.
30. Gladstone and Tribe: A Law in Chemical Dynamics; Proc. Roy. Soc., xix, 498.
31. R. B. Warder: Suggestions for computing the Speed of Chemical Reactions; Proc. A. A. A. S., xxx, 156.
32. J. H. Gladstone: Chemical Affinity as existing among Substances in Solution; Phil. Trans., Mar., 1864.
33. J. W. Draper: Chemical action of Light; Jour. Frank. Inst., xix, 469. 1837; also many others on the same subject in Phil. Mag., from 1842 to 1857.
34. H. E. Roscoe: Measurement of the Chemical Action of Light; Proc. Roy. Soc., 1857, 326; also in conjunction with Bunsen till 1862.
35. Edm. Becquerel: Chemical rays which accompany Light; Compt. rend., xiii, 198, 1841.

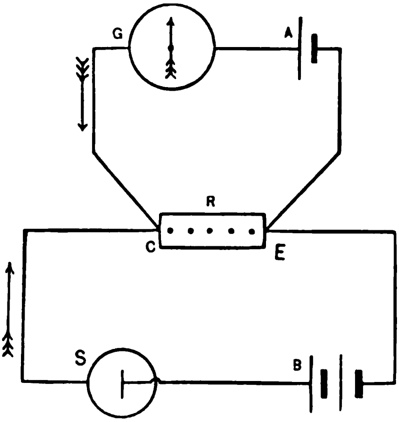
[To be concluded.]

ART. XLV.—*Relation between the Electromotive Force of a Daniell Cell and the Strength of the Zinc Sulphate Solution;* by H. S. CARHART.

THE investigation here described was carried out in the physical laboratory of the University of Berlin in the spring of 1882, and was undertaken with a view to ascertain whether the variation in the strength of the zinc sulphate solution surrounding the zinc plate of a Daniell cell affected the electromotive force, and to what extent.

It is well known that different experimenters have found different values of the electromotive force of a Daniell element. Thus Sir William Thomson found a value of 1·122 volts; Latimer Clark, 1·11; Kohlrausch, 1·138.* These different results may be partly due to difference of method; but it is easy to ascertain that slight changes in the condition of the plates or in the concentration of the solutions modify the value of the electromotive force to an appreciable extent. The method employed in this investigation was essentially the compensation method of Poggendorff.† The two poles of the battery A, the electromotive force of which is required, are connected with two points C E of a second circuit containing a battery B of higher electromotive force than A. The resistance between C and E is then varied by means of the rheostat R, till no current flows through the circuit of battery A. The difference of potential between the points C and E is then the electromotive force to be measured. By Ohm's law, the product

1.



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* Everett's Units and Physical Constants, p. 146.

† Wiedemann's Elektricität, p. 633.

of the resistance inserted between C and E and the strength of the current in the main circuit equals the difference of potential between the two points, or the electromotive force of A.

The current was measured by a silver voltameter (S) with pure nitrate of silver The resistance employed at R was in Siemens units. The deposition of silver was continued for ten minutes; the cup was then washed with great care, dried in a hot air chamber, and weighed after cooling, fractions of milligrams being obtained by observing the swing of the pointer.

The Daniell cell consisted of a U tube of the form employed by Kohlrausch in measuring the resistance of electrolytes,* the bend of the tube being much smaller than the two branches. The lower portion was first filled with a saturated solution of pure zinc sulphate; saturated copper sulphate was then added to one branch and a percentage solution of zinc sulphate to the other. The sulphates were so added that the surface of separation between two solutions in contact was quite clear and sharp. This was effected by first placing a small disc of cardboard on the surface of the liquid in the tube and then carefully pouring the other liquid on it from a pipette. No sensible diffusion took place during the time required to make the observations.

The galvanometer in the circuit of A was a sensitive one and was observed with a telescope and scale at a distance of about two meters. After a little experience a balance was readily obtained by the greater or less immersion of the silver plate in the nitrate of silver solution of the voltameter; and it was tested from time to time during the deposition of the silver and corrected if necessary. The galvanometer never showed a deflection of more than a few scale parts—perhaps five of the millimeter force divisions. The electromotive of A was thus measured with minimum liability to polarization and by a method entirely independent of the internal resistance of the cell. The only resistance required is that between C and E, and this can easily be measured by means of a rheostat.

The temperature of the rheostat and of the cell was observed at every trial. The extreme limits of variation in the temperature of the cell was 3°·2 C.

The table exhibits the results; but the final reduction, as shown in the last column, was not made till after the recent report of the Paris commission on the legal ohm, and the publication of the results of Lord Rayleigh's experiments with the silver voltameter.† The values of the electromotive force, given in the column next to the last in arbitrary units, were reduced to volts as follows:—

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* Wiedemann's Elektricität, p. 590.

† Nature, March 20, 1884, p. 495.

TABLE.

Per cent. of $ZnSO_4$	Temp. of R'eostat	Resis. in Siemens Units.	Silver deposited in one minute.	Product of resistance and silver.	Corrected for temp. of rheostat.	Mean value of product.	E. M. F. in volts.
0	20°	11	6·727 mgs.	73·997	73·997	73·997	
1	18·8	11	7·277 “	80·037	80·000	80·000	1·125
3	18	11	7·339 “	80·729	80·664	80·584	1·133
	19·5	12	6·710 “	80·520	80·504		
5	17·8	11	7·423 “	81·653	81·581	81·216	1·142
	17·3	11	7·358 “	80·938	80·851		
7.5	17·3	11	7·239 “	79·632	79 546	79·620	1·120
	18·3	11	7·250 “	79·750	79·694		
10	17	11	7·224 “	79·464	79·369	79 490	1·118
	19·3	11	7·239 “	79·634	79·612		
15	20	11	7·219 “	79·409	79·409	79·305	1·115
	18·3	11	7·205 “	79·255	79·201		
20	17·3	11	7·170 “	78·870	78·785	79·008	1·111
	17·5	11	7·210 “	79·310	79·231		
25	16 3	11	7·199 “	79·189	79·072	78·997	1·111
	16·6	11	7·184 “	79·030	78·923		

Mean, 1·122

The ratio of the Siemens unit to the congress or legal ohm is 100 to 106, or, 50 to 53. According to Lord Rayleigh a current of one ampère deposits 4·025 gms. of silver in an hour, or 67·08 mgs. a minute. Therefore if C, R and E represent current strength, resistance, and electromotive force in ampères, ohms, and volts, and *e* the electromotive force in the arbitrary unit of the table, we have the following equation,

$$\left(\mathrm{R}.\frac{53}{50}\right)(\mathrm{C}\times 67{\cdot}08)=e;$$

$$\text{whence } \mathrm{R\,C}=\frac{e}{\frac{53}{50}\times 67{\cdot}08}=\frac{e}{71{\cdot}105}=\mathrm{E}.$$

It is only necessary then to divide the quantities in column seven by 71·105 to reduce them to volts.

The method employed is amply sustained by the results obtained with a Latimer Clark standard cell. Two trials gave the same result. I give only one of them.

Time of deposition of silver,	10 min.
Resistance between C and D,	20 S. U.
Temperature of rheostat,	19°
“ Clark's cell,	18°
Weight of silver cup after deposition,	26·1963 gms.
“ “ before “	26·1453 “
Silver deposited in 10 min.,	0·051 “
“ “ 1 min.,	5·1 mgs.

$5{\cdot}1\times 20=102=e.$ $102\div 71{\cdot}105=1{\cdot}434=\mathrm{E}.$

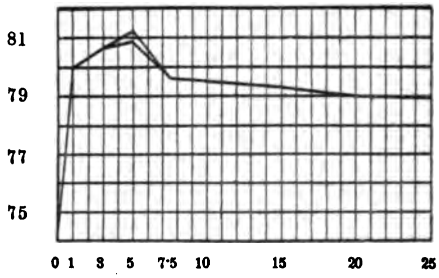
electromotive force of a Clark element is therefore 1·434 the exact value given by Lord Rayleigh* instead of the rly accepted value of 1·457 volts.

mean of all the values of the electromotive force in the lumn of the table is 1·122, which is the value obtained William Thomson by the electrostatic method, if the ty expressing the ratio between the electrostatic and elecgnetic units be taken as 3×10^{10}.

figure 2 the results of the investigation are set forth ically; the ordinates represent the excess of the quantities mn seven of the table above 74, the value obtained with ed water; while the corresponding abscissæ denote perges of zinc sulphate. It will be observed that little ion in the value of the electromotive force occurs after ng ten per cent. of zinc sulphate, and that the maximum appears to be at about five per cent. I have some reasons ubting the accuracy of the larger of the two values found the five per cent. solution. If the smaller value alone is yed the points laid off may be connected by nearly a curve.

thus appears that the variation in the concentration of nc sulphate solution is sufficient to account for the part of the discrepancy between the results obtained ferent experimenters in measuring the electromotive force Daniell cell. It would therefore seem desirable that a rd Daniell element should be so constructed as to admit ploying a zinc sulphate solution of known concentration. orm proposed by Professor G. F. Barker,† in which the ns are saturated appears to meet the requirements in this t.

2.



western University, Evanston, Ill., August, 1884.

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[*] ure, March 20, 1884, p. 495. In his Montreal Presidential address Lord h gave the value 1·435 volts.

[†] c. Amer. Philos. Soc., Jan. 19, 1883, p. 654.

ART. XLVI.—*Notice of the remarkable Marine Fauna occupying the outer banks off the Southern Coast of New England, No.* 10; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. LVI.

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Work of the Steamer Albatross in 1884.

THE exploration of the Gulf Stream region was continued this season, under nearly the same conditions as in 1883, by the steamer Albatross, Lieut. Z. L. Tanner, commander. During the four trips, between July 20 and Sept. 13, sixty-nine dredgings (at stations 2170 to 2238) were made. In most of these a large beam-trawl was used very successfully, even at great depths.*

Of these dredgings 5 were in depths between 2000 and 2600 fathoms (4 successful); 20 were between 1000 and 2000 fathoms; 24 between 500 and 1000 fathoms; 8 between 300 and 500 fathoms; 12 between 75 and 300 fathoms. Another trip has since been made to explore extensively the zone between 40 and 100 fathoms. On this trip about 24 additional dredgings were made, but the results are not yet worked out. The first trip was made while the steamer was on her way north from Norfolk, Va., and some of those stations were off the coast of Maryland, the most southern being in N. lat. 37° 57′, but most of the others have been made in the region south and southeast of Martha's Vineyard, though some of them were a long way off the coast. The five stations in depths below 2000 fathoms were more than half way to Bermuda, and nearly east of the coast of Virginia, between N. lat. 36° 05′ 30″ and 37° 48′ 30″; and between W. long. 68° 21′ and 71° 55′.

The results are highly satisfactory, both in the way of physical observations and zoological discoveries. Large numbers of additions have been made to the fauna, including representatives of nearly all classes of deep-sea animals. Many pelagic species were also secured in the surface nets and especially in the trawl-wings. Among these there are some new forms and many that have not previously been observed so far north in the Gulf Stream.

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* It is but just to say that the unusual thoroughness and remarkable success of these explorations of the Gulf Stream region have been due to the great skill and untiring zeal and energy of Capt. Tanner, who has personally superintended all our deep-sea dredging operations during the past five years. It is proper to add that his efforts have been well supported by the other officers associated with him.

The naturalists associated with the writer in the work, in 1884, were Professor S. I. Smith, Mr Sanderson Smith, Mr. Richard Rathbun, Professor L. A. Lee, Mr. B. F. Koons, Professor Edwin Linton, Mr. H. L. Bruner, Mr. J. H. Blake (as artist), Mr. J. E. Benedict (naturalist attached to the steamer), Mr. A. Baldwin, W. E. Safford, Ensign U. S N., Mr. Wm. Nye, and others. Mr. Peter Parker and R. H. Miner, Ensign U. S. N., worked on the fishes. The parties who went out dredging on the steamer varied from time to time. Usually not more than three or four naturalists besides Mr. Benedict were sent out.

Character of the deep-sea deposits.

Some very interesting and important discoveries were made in regard to the nature of the materials composing the sea-bottom under the Gulf Stream at great depths. These observations are of great interest from a geological point of view and some of them are contrary to the experience of other expeditions and not in accordance with the generally accepted theories of the nature of the deposits far from land. The bottom between 600 and 2000 fathoms, in other regions, has generally been found to consist mainly of "globigerina ooze," or as in some parts of the West Indian seas, of a mixture of globigerina and pteropod ooze. Off our northern coasts, however, although there is a more or less impure globigerina ooze, at such depths, at most localities beneath the Gulf Stream, this is by no means always the case. The ooze is always mixed with some sand and frequently with much clay-mud. In a number of instances the bottom between 500 and 1200 fathoms has been found to consist of tough and compact clay, so thoroughly hardened that many large angular masses, sometimes weighing more than fifty pounds, have been brought up in the trawl, and have not been washed away appreciably, notwithstanding the rapidity with which they have been drawn up through about two miles of water. In fact, these masses of hard clay resemble large angular blocks of stone, but when cut with a knife they have a consistency somewhat like hard castile soap, and in sections are mottled with lighter and darker tints of dull green, olive and bluish gray. When dried they develop cracks and break up into angular fragments. This material is genuine clay, mixed with more or less sand, showing under the microscope grains of quartz and feldspar with some scales of mica. More or less of the shells of *Globigerina* and other Foraminifera are contained in the clay, but they make up a very small percentage of the material.

The following are some of the special localities where these clay masses were taken:

Station 2192, in 1060 fathoms, N. lat. 39° 46′ 30″, W. long. 70° 14′ 45″. Large blocks of sandy clay, some weighing about 100 pounds. It was estimated that about a ton was brought up.

Station 2230, in 1168 fathoms, N. lat. 38° 27′, W. long. 73° 02′. Large quantity of masses of hard but sticky greenish blue clay, some masses varying to yellowish and buff colors.

Station 2171, in 444 fathoms, N. lat. 37° 59′ 30″, W. long. 73° 48′ 40″. Large lumps of bluish gray sandy mud.

In other localities, in 1000 to 1600 fathoms, the bottom is covered with or largely composed of hard, very irregular, flattened, crust-like concretions of clay and iron-oxide, with more or less manganese-oxide in the crevices and worm-burrows with which they are filled. At some localities a barrel-full, or more, of such masses were brought up, varying in size from a few ounces up to 20 pounds or more in weight and from one inch to six inches in thickness.

The following are some of the localities where such material occurred:

Station 2208, in 1178 fathoms, N. lat. 39° 33′, W. long. 71° 16′ 15″. Large quantities of hard crusty ferruginous clay. Also a rounded granite bowlder, weighing over 20 pounds.

Station 2228, in 1582 fathoms, N. lat. 37° 25′, W. long. 73° 06′. Large quantity of irregular crusty and cavernous concretions and masses of ferruginous clay, with considerable black manganese-oxide lining the holes and cracks. The lower side of many of the masses consisted of sticky bluish clay. It was estimated that about a ton of this material came up. There were adhering to these hard masses some corals, gorgonians, hydroids and bryozoa, with the brachiopods, *Discina Atlantica* and *Waldheimia cranium*, in considerable numbers.

Rounded bowlders and pebbles of granite, gneiss and other crystalline rocks occurred at a number of stations. One bowlder, station 2208, is referred to above. The following are other localities: station 2195, in 1058 fathoms, N. lat. 39° 44′, W. long. 70° 03′. A rounded granitic bowlder, about four inches in diameter. Its surface was covered with adherent species of foraminifera and some annelid-tubes. Station 2226, in 2021 fathoms, N. lat. 37° 00′, W. long. 71° 54′. A large number of pebbles and small, rounded bowlders of granite, porphyry, etc., and some coal cinders. The pebbles were more or less covered with adherent foraminifera, bryozoa, etc. Scattered bowlders and pebbles have also occurred at many other localities along the inner edge of the Gulf Stream. These have probably all been carried out there by ice from the adjacent coasts, in spring.

A curious instance, quite unique in our experience, of the occurrence of abundant relics of human handiwork was observed this year. At station 2222, in 1537 fathoms, N. lat. 39° 03′ 15″, W. long. 70° 50′ 45″, beneath the Gulf Stream, a large quantity of common bricks with mortar and soot still adhering to them was brought up in the trawl. Some were nearly entire, but most were in fragments. Annelid tubes, brachiopods,* and other forms of deep-sea life were attached to them in small quantities, showing that they had not been on the bottom very long. These may have come from some wreck, or they may have formed the deck-furnace of some whaling vessel and have been thrown overboard on the homeward trip. At any rate, the accident of hitting upon the precise locality of such relics is very curious. Otherwise than this instance we have rarely found in deep water any human traces except coal cinders from steamers.

In all our ten localities between 2000 and 3000 fathoms the bottom has been "globigerina ooze." We have never met with the "red clay" which ought to occur at such depths, according to the observations made on the cruise of the Challenger.

The temperatures observed with the improved thermometers now used on the Albatross were between 36°·4 and 37°·00 F. in 2000 to 2600 fathoms. But temperatures essentially the same as these were also taken in 1000 to 1500 fathoms, and even in 965 fathoms one observation gave 36°·8 F. It follows from these observations that nearly the minimum temperature is reached at about 1000 fathoms in this region.

The *zoological results* this year are very important. Many additions to the fauna of great depths were made and a large proportion of them are undescribed forms. Some of the fishes were of great interest. Huge spiny spider-crabs (*Lithodes Agassizii*) over three feet across were taken in 1000 to 1230 fathoms, and another very large crab (*Geryon quinquedens*) occurred in great abundance in 500 to 1000 fathoms, while in 2574 fathoms a large and strong species of *Munidopsis* was taken. Numerous species of handsome shrimp, many of them bright colored and some of very large size occurred, as usual, in the deeper dredgings. Some of these had not been taken before.

Many very interesting Echinoderms have been obtained this year and last, in addition to all those enumerated from the same region in one of my former papers in this Journal. Among these are several Holothurians, besides the two large species, *Benthodytes gigantea* and *Euphronides cornuta* described in my last paper, both of which were taken in abundance this year, the former in 904 to 2033 fathoms, the latter in 861 to 1735 fathoms. One of the new forms belongs to the genus *Ankeroderma*. Of Echini, we have taken two of the species with flexible shells (*Phormosoma placenta* and *P. uranus*) in many localities and in considerable numbers. *P. uranus* occurred in 568 to 1080 fathoms. Some of the specimens are 8 to 9 inches in diameter, and of a rich purplish color, an unusual color for deep-sea animals. *P. placenta* ranges from 458 to 1230 fathoms. Other interesting species were *Pourtalesia Jeffreysii*, in 1255 to 1555 fathoms; *Aërope rostrata*, in 1467 to 1608 fathoms; *Aceste bellidifera*, in 1467 fathoms; *Urechinus Naresianus*, in 1309 fathoms; *Salenia varispina*, in 547 fathoms; and *Aspidodiadema Antillarum*. The last had not been taken before north of the West Indies. A large specimen occurred in 991 fathoms. A good specimen of *Rhizocrinus* was taken in 2021 fathoms, station 2226.

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* One of these brachiopods, which occurred on the bricks in considerable numbers, is *Atretia gnomon* J., which has not been recorded hitherto from off our coast.

The additions to our list of starfishes have been numerous and important during the last two years. Two species of *Brisinga* have been taken in many localities, sometimes in large numbers. One of these has often been obtained and preserved nearly entire. It is a handsome species,* with long slender arms, usually 11 or 12 in number, but varying from 9 to 13. The other is a coarser species,† which usually comes up broken into numerous fragments, by spontaneous division.

* *Brisinga elegans* V., sp. nov. Arms long and slender, usually 11 or 12, but varying from 9 to 13, rounded and finely spinulose toward the base, very slender, angular and transversely ribbed distally. Disk small, round, a little swollen, covered dorsally with small acute spinules, standing singly or two or three together. On the proximal part of the arm the spinules are small and sharp, scattered in small clusters, which are sometimes elongated transversely. These spinules are surrounded by clusters of minute pedicellariæ. A little farther out the spinules and pedicellariæ begin to be arranged in indefinite transverse groups, and still farther out there are regular and rather prominent broad, flattened, sinuous, tranverse groups of pedicellariæ, which extend nearly to the median dorsal angle: these continue to the end of the arm. The arms have on each side a lateral row of long slender spines, covered by fleshy sheaths which are clavate at the tip and bear numerous minute pedicellariæ. The lateral spines are longest at the middle portion of the arms. On each adambulacral plate a single slender, acute spine projects directly inward beyond the middle of the groove, so that those on opposite sides interlock. The ovaries are clustered in the basal part of the arms and discharge by a basal pore on each side. Color in life salmon or pale orange: in alcohol soon becoming yellowish white.

Greater radius, 275^{mm}; lesser radius, 12^{mm}; length of the largest lateral spines, 20–25^{mm}; breadth of arms, where largest, 10^{mm}. Some specimens have occurred larger than this, but the rays were broken.

Taken at station 2035 and at several other localities in 1883, and at stations 2205, 2209, 2211, 2220, 2226, 2229, in 1884, in 906 to 2021 fathoms. At station 2229 about thirty specimens were taken, several of them in good condition.

† *Brisinga costata* V., sp. nov. A large species, usually with eleven arms, closely allied to *B. coronata* Sars. The disk is round, swollen, roughly spinulose, the spines small, sharp, standing singly or in groups of two, three or more. Arms very long, strongly depressed, somewhat swollen toward the base, but broad and angular and carinated farther out, gradually tapering. The basal portion is crossed by curved, sinuous, very prominent, narrow ribs, some continuous and some interrupted, surmounted by a row of small, short spinules. Transvere raised bands of pedicellariæ alternate with the ribs. The adambulacral plates bear usually three slender, fluted, glassy spines in a transverse row at about the middle of the plate, the uppermost longer and larger than the others the third being small and slender; in addition to these there is a smaller, more slender, inner spine, situated at the distal end of each plate and projecting more than half-way across the groove. All the spines bear swollen sheaths of minute pedicellariæ. Diameter of disk, 28^{mm}; breadth of arms, near base, 11^{mm}; length of longest spines, 12^{mm}.

Station 2310, in 991 fathoms (No. 7820), and also from several other localities.

A single large specimen of *Zoroaster fulgens* Thomp. was
en at station 2206, in 1043 fathoms, associated with the
ch more common *Z. Diomedeæ* V. The two are very easily
tinguished. The curious little pentagonal star fish described
Thompson (voyage of the Challenger) as *Porcellanaster cæru-*
s was taken in numbers at many localities, both this year
l last, in 906 to 1467 fathoms. Its cœrulean color is due
ly to the bluish mud, with which its large stomach is usually
ed, showing through the translucent integument. The real
or is buff or pale salmon. *Archaster grandis* V. occurred
ındantly in 965 to 2033 fathoms, and *Benthopecten spinosus*
in 855 to 2021 fathoms. A large and handsome new
chaster (*A. robustus* V.)* remarkable for its high, squarish
ns and smoothish appearance, was taken both this year and
t, at several localities, in 924 to 1467 fathoms. Another
w and very elegant species of this genus (*A. formosus* V.)†
s taken sparingly in 1594 to 2021 fathoms.

Archaster robustus V., sp. nov. Disk rather small, thick. Arms five, elon-
ed, thick, squarish, with high and nearly perpendicular sides, tapering very
dually from near the base to the rather slender, acute tips. Dorsal surface of
disk and arms almost entirely covered with closely crowded paxillæ, the
er ends of the marginal plates forming only a very narrow margin along the
s. The paxillæ over the central position of the disk are very much smaller
more crowded than on the arms; immediately around the prominent abac-
l pore they become remarkably fine and close; over the dorsal surface of the
s and along the margins of the disk they are rather regular in form and of
orm size, each bearing a flattened group of very short, close, blunt spinules.
madreporic plate is small, flat, depressed, situated about one-third the distance
n the margin to the center of the disk. The marginal plates are narrow, very
, and each is surmounted by a small, short, conical spine, forming a row along
margin of the arms; laterally they are closely covered by small scale-like
ules, sometimes with two or three small, acute spinules below the middle.
ventral plates are small, densely covered with the same, small, flattened scales.
interbrachial spaces are very small and scaled. The adambulacral plates
ect inward and each bears an acute group of small, crowded, flattened spinules
which the central one is longest and acute, the other scale-like ones surround-
and supporting it externally. The oral plates form a long, narrow ellipse,
h bearing two or more rows of small, short, flattened spinules, those at the
er end becoming a little more prominent but flattened and scarcely spine-like.
bulacral grooves very broad. Suckers very large, conical, with small, papilli-
n tips. Color in life light buff or salmon.

rather small specimen measures from center of disk to interradial margin,
m; from center of disk to tip of rays, 66mm; height of disk, 14mm; breadth of
s near the base, 13mm; height of marginal plates, 10mm; diameter of suckers,
m. Specimens have been taken at least twice the size of the above.

he larger specimens are still more remarkable for the great elevation and
areness of the arms. In very young specimens this feature is less prominent.

his species is easily distinguished from all the others by the high perpen-
lar sides of the arms, and by the peculiar form and scale-like covering of the
ginal and ventral plates.

aken at many localities, in both 1883 and 1884, in 924 to 1467 fathoms.

Archaster formosus V., sp. nov. An elegant species, with a moderately large
tagonal disk, having regular incurved borders, and rather long arms, quickly
oming nearly round and very slender distally. The arms have, except close to
base, a very narrow median dorsal area, bearing only a single row of paxillæ,
the tip is terminated by a single, elongated plate. The disk is closely cov-

Ophiurans of many species were very abundant in numerous localities. Among those of special interest are *Ophiomusium armigerum*, abundant and large, in 1731 to 2369 fathoms; *Ophioglypha convexa*, in 1608 to 2574 fathoms; *O. lepida?*[*] taken in vast numbers at station 2221, in 1525 fathoms, and common in many other places, in 1168 to 2574 fathoms.

A fine large new species of the genus *Ophiochiton* (*O. grandis* V.)[†] was taken, both last year and this, in 888 to 1080 fathoms. This genus was not before known in this region.

ART. XLVII.—*Note on the Cortlandt and Stony Point Hornblendic and Augitic rock;* by JAMES D. DANA.

IN my paper on the rocks of Westchester County, N. Y., I described certain massive hornblendic and augitic rocks, for the most part chrysolitic, from the town of Cortlandt and from

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ered with rather large, angular paxillæ, those in the center becoming much smaller. The paxillæ bear close clusters of short, thick, obtuse or rounded spinules, about 30 to 36 on the largest. The dorsal marginal plates are higher than broad, except distally; they are regular, little convex, and covered with small, flattened granules. The lower plates are similar to and opposite the upper ones, their upper half bearing granules which change to small sharp spinules lower down, and in some specimens several longer spinules are developed on the central part of some of the plates. The ventral areas are small and covered with rather large plates, which bear small obtuse spinules, a somewhat larger one usually occupying the center of each plate. The adambulacral plates project strongly inward with deep notches between them. Each bears a convex group of six to eight slender spinules directed inward, while on the middle of the plate there is a group of eight to ten smaller, rough, divergent spinules. Color in life pale buff.

Greater radius of one of the largest specimens, 74^{mm}; lesser radius, 18^{mm}; breadth of arms in middle, 6^{mm}.

This species was taken in 1883 at stations 2041, 2042, 2043, in 1467 to 1608 fathoms; and in 1884 at station 2174, in 1594 fathoms (No. 7963); and station 2226, in 2021 fathoms (No. 8151), three specimens.

[*] This resembles *O. lepida* Lym., but the disk is sparcely covered with small slender spines. It may be designated as var. *spinulosa*.

[†] *Ophiochiton grandis* V., sp. nov. A large species with the disk rounded, carinated at the margin, its surface covered with numerous unequal imbricated plates, becoming larger and more distinct toward the margin. The radial plates are rather small, well-separated, with the inner ends strongly divergent, irregularly ovate in form. The arms are long, stout, depressed, distinctly medially carinated below, less so above. The arm-spines are three, rather long and tapered, the upper one longer than the other. The tentacle-pores are large and each has one large, round, flat scale. The ventral arm-plates are broader than long, emarginated laterally with the outer corner elongated and acute, an obtuse prominent lobe in the middle of the outer margin. Oral plates prominent, convex, rather small, ovate, the outer edge broadly rounded, the inner end acute, the sides a little incurved. Mouth papillæ five to seven, the outer ones much broader and flatter than the inner ones, which are conical and acute. A similar median papilla stands above the teeth. Color in alcohol dull yellowish brown.

Diameter of disk, 30^{mm}; breadth of arms at base, $4·5^{mm}$; length of longest arm-spines, $3·5^{mm}$.

Stations 2209, 2217, in 924 to 1080 fathoms, 1884; station 2116, in 888 fathoms, 1883 (No. 6624).

Stony Point on the opposite shore of the Hudson. I showed, by the occurrence of dikes in the limestone of Verplanck and other peculiarities, that they were once in fusion or a plastic state; but I suggested that the fusion may have been connected with the metamorphic action that crystallized the rocks of the region, and that the peculiar constitution of the rocks may have come from previous igneous ejections and tufaceous deposits.

Since the publication of my paper, a north-and-south cut has been made through the rocks of Stony Point for the "West Shore" railroad, and it is now clear that these rocks are of true *eruptive* origin. The line of the railroad extends southward along the shore just east of Dunn's house (see map on page 112 of vol. xxii of this Journal for August, 1881*), and continues in nearly the same direction across the Point, passing through, in succession, the "soda granite,"† the chrysolitic rock and the mica schist. The exposed section of the chrysolitic rock (which is mainly chrysolitic hornblendyte) is about 250 yards long. In the section it appears to constitute a dike about N. 60° E. or S. 60° W. in course; but the map shows that the mass extends at the surface hardly a hundred yards west of the railroad, the mica schist being the surface rock beyond this distance.

The mica schist (a gneissoid mica schist) exposed to view in the railroad cut south of the igneous mass becomes increasingly flexed as it nears the dike; but this increase of flexure in its beds has nothing to do with the eruption of the hornblendyte, while it has some connection with the origin of the soda-granite, as shown near Cruger's on the east side of the Hudson.

The *south* wall of the dike or erupted mass, or the plane of contact with the mica schist, has a strike of about N. 55° E., and dips 80° to the northward. Some effects of the heat from the melted rock appear in the schists, and among them there are in a few places greenish spots or nodules.

The *north* wall of the chrysolitic hornblendyte mass is not well exposed to view but appears to be nearly vertical. Against it there is, first, for about thirty-five feet, *limestone* which is in part a very coarse limestone-breccia having the igneous rock as its cement, but in places shows nearly vertical bedding, parallel nearly to its junction with the next rock north, the soda-granite. This breccia contains large angular masses of limestone, and resembles the limestone breccia of Verplanck Point (described on pages 201 and 202 of volume xx of this Journal, September, 1880), in its appearance, its cement and the very small effect of heat at the contacts with the cement beyond some mutual impregnations. The limestone at Verplanck

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* The scale of the map is 800 feet to the inch.

† The "rock" I have since named *hemidioryte*, the name often used in lithology, micadioryte, being bad.

Point is the same that outcrops elsewhere on the Point, and is evidently the eastern part of the formation largely exposed on the west side of the river from the base of Stony Point to and beyond Tompkins Cove; and it is hence safe to conclude that the limestone by the side of the Stony Point dike is a portion of the Tompkins Cove formation.

The junction plane of the limestone and soda-granite has the direction N. 70° E., and dips 67° to the northward; and but for the intervening limestone it would be regarded as the north wall of the dike. North of the dike, along the section, the soda-granite is intersected by blackish, narrow veins or vein-like dikes, a foot or so wide, two of which cross one another like the bars of the letter X. There is also a dike of the chrysolitic hornblendyte eighteen feet wide.

While the facts prove the hornblende rock and the related augite rock to be eruptive, they throw no new light on the origin of the "soda-granite." They show, like the facts from Verplanck Point, that the igneous eruptions took place *subsequently* to the era of the limestone, mica schist and soda-granite. And the limestone is, as I have proved, younger than the Archæan of the Highlands, and probably of Lower Silurian age, as recognized for the Tompkins Cove limstone by Professor G. H. Cook.

SCIENTIFIC INTELLIGENCE.

I. Physics.

1. *National Conference of Electricians.*—On the 17th of July, the President of the United States, in pursuance of an act of Congress, appointed an Electrical Commission charged with the duty of conducting, in the name of the United States Government, "a National Conference of Electricians in Philadelphia in the autumn of eighteen hundred and eighty-four." This Commission consisted of the following persons: H. A. Rowland, M. B. Snyder, J. Willard Gibbs, John Trowbridge, C. A. Young, C. F. Brackett, W. H. Wahl, Simon Newcomb, G. F. Barker, E. J. Houston, R. A. Fisk and F. C. VanDyck. The Commission met on the 9th of August, completed its organization and sent out invitations to about one hundred and fifty American and to twenty-four foreign men of science, asking them to take part in the Conference above mentioned. The Right Hon. Lord Rayleigh, the Right Hon. Sir Lyon Playfair and Professor Sir Wm. Thomson were invited to act as Vice-Presidents of the Conference.

On the 8th of September, the National Conference of Electricians met at 3 o'clock P. M. The meeting was formally called to order by Professor Simon Newcomb, who introduced the President of the Conference, Professor Rowland. His opening address, which occupied nearly an hour in delivery, was mainly an exposition of the progress of electrical science viewed from the standpoint of theory. After a glowing eulogium of Archimedes, the man who, according to Plutarch "possessed so high a spirit, so profound a soul and such treasures of scientific knowledge that though the inventions (referring to his military engines) had now obtained for him the renown of more than human sagacity, he yet would not deign to leave behind him any commentary or writing on such subjects; but repudiating as sordid and ignoble the whole trade of engineering and every sort of art that lends itself to mere use and profit, he placed his whole affection and ambition in those purer speculations where there can be no reference to the vulgar needs of life; studies, the superiority of which to all others is unquestioned and in which the only doubt can be whether the beauty and grandeur of the subjects examined or the precision and cogency of the methods and the means of proof, most deserve our admiration"—he discussed the relation of the investigator to the inventor. "Pure science must exist before its applications, and the truths of pure science are far more reaching in their effects than any of its applications; and yet the applications of science often have a much more immediate interest for the world at large than many discoveries in pure science which will finally revolutionize it both physically and mentally. They both have their importance and both are at work in causing that intellectual and material progress in which the world is now pushing forward with grand steps." "The simple experiment of the amber remained without investigation for 2200 years. Had the reasoning of many modern persons been followed we should never have had a science of electricity. Why should anybody investigate this phenomenon, this feeble force which could only attract a few particles of dust? The world could eat, drink and take its ease without doing anything in the matter and it did so for more than 2000 years of intellectual, moral and physical degradation. Then the awakening came and men began to feel that they were reasoning beings. They began to see that there were other pleasures in the world besides animal pleasures, and that they had been placed in this wonderful universe that they might exalt their intelligence by its proper study. No question of gain entered into the minds of these early investigators, but they were led by that instinct toward truth which indicates the highest type of man." "The name of Faraday needs no eulogy from me, for it stands where it can never be hidden and the spark which Faraday first kindled now dazzles us at every street corner. No wealth came to him although he had only to hold out his hand for it. But the holding out of one's hand takes time which Faraday could not spare from his labors and so the wealth which was rightly his went to others. Who will follow in his footsteps and live such a life that the thought of it almost fills one with reverence? It is not only his intellect which we admire; it is his moral qualities which fill us with awe, his noble and unselfish spirit." The address then passed to consider the progress of electrical measurement, the necessity for a governmental bureau of electric standards and the vexed question of the nature of electricity, closing with a few well chosen words on the relation of theoretical to applied science. "Let not then the devotee of pure science despise practical science, nor the inventor look upon the scientific discoverer as a mere visionary person. They are both necessary to the world's progress and they are necessary to each other. To-day our country by its liberal patent laws encourages applied science. We point to our inventions with pride and our machinery in many of the arts is not surpassed. But in the cultivation of the pure sciences we are but children in the eyes of the world. Our country has now obtained wealth and this wealth should partly go in this direction. We have attained an honorable position in applied science and now let us give back to the world what we have received in the shape of pure science. Thus shall we no longer be dependent but shall earn our science as well as inventions. Let physical laboratories arise; let men of genius be placed at their head, and best of all let them be encouraged to pursue their work by the sympathy of those around them. Let the professors be given a liberal salary, so that men of talent may be contented. Let technical schools also be founded and let them train men to carry forward the great work of applied science. Let them not be machines to grind out graduates by the thousand irrespective of quality. But let each one be trained in theoretical science, leaving most of his practical science to be learned afterward; avoiding, however, overtraining. Life is too short for one man to know everything, but it is not too short to know more than is taught in most of our technical schools. It is not telegraph operators but electrical engineers that the future demands. Such a day has almost come to our country and we welcome its approach. Then and not till then should our country be proud and point with satisfaction to her discoveries in science pure and applied, while she has knowledge enough to stand in humiliation before that great undiscovered ocean of truth on whose shores Newton thought he had but played."

Professor Sir Wm. Thomson followed with a few remarks, in which after endorsing the line of thought in the address just delivered, he considered the great advantages likely to flow from the Conference, particularly in the direction of international standards and an International Bureau. The necessity for exact instruments of measurement prompt and reliable in their indications is every day increasing, and these instruments must measure the hundred thousandth or the millionth of an ampère as required by Langley, or the five thousand ampères needed in an Edison central station. He closed with a cordial eulogy of Joseph Henry.

The Conference continued in session through the entire week. The subjects brought forward were: "Work of the U. S. Signal Service in relation to Atmospheric Electricity and Earth Currents," the discussion being opened by Professor Abbe and Lieutenants Greely and Allen. "The Adoption of the International Electrical Standards," discussion opened by Professor John Trowbridge. "The Establishment of a National Bureau of Physical Standards," discussion opened by Professor Snyder. "The Theory of the Dynamo-electric machine," discussion opened by Professor Rowland. "The Electrical Transmission of Energy," "Storage Batteries." "Measurement of Large Currents." "Induction in Telephone Wires, Long Distance Telephoning, and Underground Wires." "Applications of Electricity to Military and Mining Engineering," "The Electrical Investigation o the Physical Qualities of Structural Metals," discussion opened by Capt. O. E. Michaelis. "Lightning Protection."

The Committee to which was referred a communication from Gen. Hazen, Chief Signal Officer, on Atmospheric Electricity and Earth Currents, consisting of Professor Abbe, Lieutenant Allen, Professor Trowbridge, W. W. Jacques, F. N. Gisborne, W. H. Preece and Professor Nipher, made a preliminary report on Friday, as follows: "The Committee recommends to the National Conference and to the United States Electrical Commission: (1) That the Government be urged to take steps to secure on a large scale observations of atmospheric electricity and the strength of earth currents. (2) That the methods of observation and reports conform as far as possible with those about to be disseminated by the International Bureau of Telegraphic Administration at Berne. (3) That the Government appoint a permanent Committee of five electricians to coöperate with the Chief Signal Officer of the Army in organizing this service, and (4) That this Committee shall include, besides others, the electricians of prominent companies, such as the Western Union Telegraph and the Bell Telephone Companies and others of wide experience."

The Committee to which the Standard of Light was referred consisted of Professor John Trowbridge, W. H. Preece, Professor E. C. Pickering, Professor C. R. Cross, Professor G. F. Barker, Mr. T. A. Edison and Major Heap, U.S. A. The Committee on the establishment of a National Bureau of Physical Standards consisted of Professors Newcomb, Rowland, Wead and W. A. Rogers. The latter Committee reported on Thursday as follows: "Whereas the recent rapid development of the applications of electricity requires the adoption and legalization of common standards of electrical measures to form the basis of contracts for the supply of electricity; and whereas the realization of such standards requires that all instruments for electrical measures be tested and verified by one central authority: Therefore, be it Resolved, That this Conference deems it of national importance that Congress, in pursuance of its constitutional authority to fix a standard of weights and measures, should fix standards of electrical measures, and in order to secure the use of said standards should establish a Bureau charged with the duty of examining and verifying instruments for electrical and other physical measurements. Resolved, That the President of this Conference be requested to communicate the above resolution to Congress through the proper official channels. Resolved, That the U. S. Electrical Commission conducting this Conference be requested to appoint a suitable committee to represent the Conference before Congress and to move for such legislation as will secure the object of these resolutions."

Extended discussion was had upon accepting the results of the International Electrical Conference held in Paris. With regard to the ohm, Mr. A. L. Kimball gave the results of Professor Rowland's experiments as 106·278 centimeters for the length of the column of mercury one square millimeter in section which has one ohm resistance; and Sir Wm. Thomson said he thought if the Paris Conference had had this result before them, it would have adopted 106·2 in place of 106. But this value is only provisional and the discussion may in a few years be reopened. The discussion on Dynamo-machines was the fullest of the session, that on Secondary Batteries coming next to it. The results of the Conference cannot fail to be of great value to electrical science, and a more frequent interchange of views similar to this in its character must contribute materially to a healthier and more rapid progress.

The Conference adjourned on Saturday, Sept. 13th, subject to the call of the chairman.*

2. *Determinations of Vapor density of bodies with low boiling points and bodies with high boiling points.*—Nix von Klobakow reviews the methods of previous observers and describes an apparatus for the determination of the vapor density of substances with low boiling points, which in its general features resembles a weight thermometer. The details are fully described in his paper. By means of this apparatus one can work with a very small quantity of the substance. If the weighing of the substance can be depended upon to the fourth decimal place five milligrams of the substance will give precise results. He terms the instrument a vapor density dilatometer. In order to obtain the vapor density of substances which have high boiling points he used an apparatus which can be described as an aräometer, a glass vessel with an opening at its lower part, which allows a part of the liquid which fills the aräometer to flow out, when the vapor or air or gas which fills the upper portion of the aräometer expands. This aräometer is connected with a weighing apparatus which enables one to measure the pressure of the enclosed vapor. This instrument is called a vapor-density aräometer. The results obtained by both instruments agree closely with the results obtained by calculation.—*Ann. der Physik und Chemie*, No. 8, 1884, pp. 466–510. J. T.

3. *Normal elements for Electrometric measurements.*—The need of a suitable practical unit of electromotive force has long been felt. The zinc and mercury element of Latimer Clark is very

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* The New York Electrical World published a very full and accurate report of the proceedings of the Conference, to which we here acknowledge our indebtedness.

ful, but its electromotive force is found to change with the perature, and also to undergo modifications when the cell is rt circuited. A Daniell cell suitably prepared can be made to e an electromotive force of about one volt; but in the form of in which a porous cup is employed diffusion is constantly ng on and thus modifying the electromotive force. A water tery is generally employed to charge the quadrants of an elec- meter but the electromotive force of such an element changes er a short interval. Beetz found the electromotive force of a c copper element filled with spring water to be 0·992 volt. examining three cells of his water battery which had been ding a year, he found the following differences of potential 38, 0·678, 0·724, giving a mean of 0·743 volt. Beetz proposes following new form of cell for constant electromotive force: ine alabaster plaster of Paris is mixed with concentrated sul- te of copper solution to about the consistency employed in king plaster casts, and some more with concentrated zinc sul- te solution. A U-shaped glass tube, of 4^{mm} diameter and with s 22^{cm} long was partly filled with the one paste, and after it had was filled with the other, so that the two were in close contact. opper wire was introduced into the copper paste before it had and a zinc wire into the zinc paste. The upper part of each was cleared from plaster and filled up with paraffine." This gives an electromotive force of about 1·056 volt. It is prac- lly uninfluenced by change of temperature and by short cir- ing. This cell promises to be very useful in all observations h a quadrant electrometer, especially when this instrument is d for continuous registration of atmospheric electricity.—*Ann. Physik und Chemie*, No. 7, 1884, pp. 402–410. J. T.

. *Wave-lengths in the Infra-red portion of the solar spectrum.* he method of phosphorescence used by Henri Becquerel ena- s one to see at a glance the whole region which is under inves- tion, and Becquerel claims that the method allows the erver to explore the region further than by means of photo- phy, and in this respect is not exceeded by the bolometer or rmopile With a very sensitive phosphorescent agent the ails of the infra-red region can be observed by the phospho- ent method far better than by Langley's bolometer. The hod employed is to throw a beam of light upon a diffraction ting. The rays were concentrated by a lens, they then trav- d a bisulphide of carbon prism whose sides were normal to slit and the lines of the grating, and formed upon the phos- rescent substance a series of oblique spectra in which the iations with spectra of different orders were juxtaposed and superposed. The slit was sufficiently narrow to enable one see clearly the principal lines of the luminous spectra, and by paring the position of the lines and bands of the infra-red of first spectra with the known lines of the second and third ctra one could obtain their wave-lengths. A table of wave- gths is appended to the author's paper.—*Comptes Rendus*, t. 1, 1884, pp. 418–420. J. T.

II. GEOLOGY AND NATURAL HISTORY.

1. *Untersuchungen über die Entstehung der altkrystallinen Schiefergesteine* mit besonderer Bezugnahme auf das Sächsische Granulitgebirge, etc., von Dr. JOHANNES LEHMANN. 278 pp. 4to, with five plates on copper, and an atlas of 28 plates containing 159 photographic representations of rock structures. Bonn: 1884. (M. Hochgürtel.)—This work is a most important contribution to the literature of metamorphism. Whether we entirely agree with the conclusions of the author or not, we cannot fail to be impressed with the amount of material collected as the result of nine years of careful work, the skillful arrangement of this material so as to lead logically to the conclusions reached, and the relation which the author has discovered between some of the most diverse geological phenomena—exhibited by the crystalline schists, by viewing them from a single stand-point. Further, he is careful to distinguish between what is fact and what theory. Although probably few geologists would at present be willing to accept the extreme application of all the principles enunciated, all will find much in the book to agree with their own observations.

The key-note of the whole work is the influence of orographic forces in regional rock metamorphism, which, using Lossen's term, the author designates "*Dislocation metamorphism.*" Where rocks are most tilted and crumpled, there they are most highly crystalline. The action of pressure is twofold according as it affects the *mineralogical composition* or the *structure* of the rock-mass. In nearly every case the two processes go hand in hand. It is conclusively shown how abundantly secondary mica, especially biotite, is developed wherever the rocks have undergone crushing or sliding; and other minerals, such as andalusite, quartz, garnet, rutile, etc., often appear to have a similar origin. By the same means pyroxene is converted into hornblende, as is admirably illustrated in the gabbros of Rosswein and Penig in Saxony.

But of greater importance are the structural alterations which enormous pressure may produce. Heim and others in Switzerland have shown that, when enclosed on all sides, even rocks may be moulded like a viscous mass. Lehmann advocates rather a plasticity, like that of wet clay, produced by a crushing and sliding of the smallest particles upon each other and a re-cementing by abundant mineral secretions. In this manner, a tightly enclosed mass may, both by stretching and compression, be converted, not only into a perfectly schistose rock, but even into one whose constituent minerals are arranged in parallel bands or layers. Hence the possibility of the change of eruptive masses into schists. As Professor J. D. Dana maintained as long ago as 1843, so Dr. Lehmann considers schistose structure in a crystalline rock as no evidence whatever of sedimentation. He therefore agrees with Naumann in considering the Saxon granulite area of eruptive origin. He goes so far as to state that even the most complicated system of intertwining dykes may by pressure be altered to a conformable series of schists. According to the author's view, the granulite was originally an intrusive mass which impregnated the surrounding sediments and locally metamorphosed those at a greater distance, but itself cooled far below the surface. Subsequently, when the area was raised to a mountainous tract, it was forced upward in a solid state by pressure, which at the same time imparted to it its schistose and banded structure, while it converted the impregnated slates into gneisses and the others into mica schists.

The extensive role attributed to sediments, broken and again cemented by eruptions of granitic material, thus forming rocks which are neither purely igneous nor yet altogether sedimentary in their origin, is very interesting, but can be only barely mentioned here. Important also are the conclusions arrived at by the author that the petrographical character of a crystalline rock is no criterion of its age, and that essentially the same product may be formed by the regional metamorphism of rocks originally entirely different in their characters. For instance, certain sericite schists he regards as produced from acid eruptive rocks, while others, indistinguishable from them, were once sediments.

Little justice can be done to this elaborate memoir, whose every page is full of suggestion, in the present short notice, and hence only a few of the most important results are here alluded to. Stated by themselves they may seem somewhat startling; for their justification as well as for that of many more of almost equal interest, we can only refer the reader to the work itself, which, whatever be one's geological beliefs, cannot but repay a careful perusal.

In conclusion, too high praise cannot be bestowed upon the photographic illustrations of rock structures, taken in part by transmitted light from but little magnified microscopic sections, and in part by reflected light from carefully polished hand specimens; they permit of a study which is hardly less satisfactory than would be that of the original specimens. G. H. W.

2. *Note on the origin of bedding in so-called metamorphic rocks*, by JAMES D. DANA.—The views presented in the work of Dr. Lehmann, noticed above by Professor G. H. Williams, are of so much interest that I add here some illustrations of the chief point from my observations in America, where metamorphic rocks are exhibited under very varied conditions over large areas. In 1843 (as Prof. Williams states), previous to making these observations, having but a year before arrived in this country after four years abroad spent partly among volcanic islands of the Pacific and on portions of its volcanic borders, I put forth the hypothesis that granite areas had been volcanic centers, and that the gneisses, or schists, about such an area were portions of the volcanic outflow.* At that time I thought well of the new idea, for I had seen volcanic rocks that were schistose. Wider experi-

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* This Journal, xlv, 104.

ence among the metamorphic rocks of New England soon satisfied me that the conclusion was wrong, and consequently, it is nowhere repeated in any of my later publications.

It is true that a schistose structure may be induced by pressure. But the question is—How far is this a fact in regions of gneiss and other bedded crystalline rocks. The following facts bear on the question.

(1.) A dozen miles east of New Haven, Conn., at Stony Creek, a thick bed of rock varies laterally in the course of a few rods (as in many other places in the region) from granite to gneiss, and then, between layers of the gneiss, there is a bed of black mica schist, made mostly of black mica or biotite. The beds are nearly horizontal. It looks like stratification.

(2.) From five to nine miles west of New Haven, a fine-grained, garnetiferous mica schist is the surface rock. Going westward, it first bends in a synclinal as shown by the divergent dips; then a mile beyond, in an anticlinal (large granite veins occurring along the axial region), and ends at Derby, where the dip is 90° to 80° W. Beds of feebly crystalline limestone occur in this range of mica schist, and show by their position, that the schistosity conforms to the bedding. The garnets increase in size westward from a diameter of $\frac{1}{20}$ in. to $\frac{1}{8}$ in., and the schist becomes concurrently coarser, yet nowhere coarse, illustrating well one of the principles recognized by Dr. Lehmann—and by the Professors Rogers, geologists of Virginia and Pennsylvania, more than forty years since.

At Derby the mica schist ends by alternating in thin layers with gneiss; the garnets in the first gneiss layers enlarge to $\frac{1}{4}$ to $\frac{1}{2}$ inch; the gneiss becomes coarser to the westward and varies from common to porphyritic. Then follows, with perfect parallelism in bedding, a great formation of coarse gneiss, the most of the gneiss porphyritic, with the feldspar crystals as large as the thumb, and other portions of it coarsely micaceous.

The case looks like one of stratification, of successive deposits or strata, with repeated interstratification at their junction.

(3.) The gneiss formation which commences at Derby continues westward with much mica, free schistosity, and eastward dip—the dip indicating a synclinal at Derby. Three to six miles west of Derby it bends over in a very gentle anticlinal, the eastward dip diminishing first to 20° and then to 10° and less, and the beds continuing nearly horizontal for more than two miles, after which they pitch westward and so continue farther west. In the axial region of this anticlinal occur nearly horizontal beds of crystalline limestone, one of them large, with gneiss in layers conformable to it above and below; and to the south in the town of Trumbull, the limestone is 100 feet thick, and some hornblendic schist in places adjoins it.

Here is unquestionably true stratification, the limestone stratum setting aside all occasion for doubt. Pressure bends and displaces rocks; but it does not insert limestone beds, or make them out of gneiss.

(4.) In northwestern Connecticut, a mile north of the Lime Rock railroad station (and in view from it), a bluff of crystallized limestone, about 300 feet high above its base, is capped by a stratum of coarse garnetiferous, staurolitic mica schist; the two rocks are nearly horizontal in position. As doubts are easy, I may add that I have been up the front and over the top.

Here is stratification, beyond question. And as the same limestone continues far northward into Berkshire without interruption, and the same schist makes or caps ridges through the limestone area as far as it goes, it is true stratification as far as these rocks go. To pressure are owing the flexures and other mechanical effects, and to friction from displacement and the attending pressure the crystallization, as has long been recognized, and nothing else.

(5.) In many parts of western Massachusetts or Berkshire County, and in Canaan, Connecticut, crystalline limestone, mica schist, and the kind of sandstone called quartzyte (for all the quartzyte shows the sand grains and the most of it is well-bedded) occur interstratified, lying in nearly horizontal beds and in bold flexures, as parallel with one another as the boards in a pile. Some of the quartzyte is a conglomerate. The same rocks extend together, far into Vermont, with the same relations as to position.

All this looks like stratification, and stratification of great wide-spread formations, not as the bedding effects of pressure on rocks within "tight" or confined limits. No appeal to the compression of a region of dikes and veins accounts for any one feature of the region.

(6.) In the towns of Rutland, Sudbury, Whiting, Middlebury and others, in central Vermont, the crystalline limestone, which is a part, by direct continuation, of that of Berkshire, and is accompanied by the same quartzyte and mica schist, contains fossils; and, in the belt of West Rutland valley, fossil corals, crinoids and shells of mollusks occur in some of the layers, while others afford some of the best of Vermont marble and contain its largest marble quarries. The mica schist on the west side and the black slate on the east of the West Rutland limestone are conformable with it in bedding. In central Vermont, moreover, the quartzyte adjoining the limestone region has afforded fossils.

Here is decided stratification of beds of sedimentary origin—beds of fossiliferous limestone (now crystalline), of quartzyte or sandstone and of mica schist—as true stratification as in any region of stratified rocks over New York and the States west.

(7.) In some Pennsylvania valleys numerous iron ore beds (limonite or brown hematite) occur in the limestone of what the Geological Survey calls No. II, or that corresponding to the Calciferous, Chazy and Trenton groups (Lower Silurian); and they are situated for the most part near the junction of the limestone (a rock upturned in flexures) and the overlying and bordering slates. The above-mentioned age of the limestone and of the slates has been determined from their fossils.

Along the eastern border of the State of New York, through the towns of Amenia, Northeast, Ancram, Copake and Hillsdale, occur in the valley region west of the Taconic Range, in a limestone belt, similar deposits of iron ore to those of Pennsylvania, having the same features and indicating a like method of origin; further, they are situated mostly near the junction of the limestone and the overlying slates; and the limestone in the part of the same belt between Copake and Poughkeepsie contains fossils of Calciferous and Trenton age.

The evidence of true stratification and for the Lower Silurian age of the beds is as good for the New York region as for the Pennsylvanian; and yet the limestone is more or less crystalline, and the slates are garnetiferous mica schists.

In conclusion I observe that the study of the stratigraphical relations of so-called metamorphic rocks is not solely a study of the beds of a slate, or of a gneiss, or of a mica schist or other single rock, but of the relations of extensive formations of gneiss, mica schist, hornblende schist, quartzyte or limestone and other rocks, to one another; and where such an investigation is undertaken, the geologist will have no occasion long to doubt whether he is studying *stratified* rocks or not. I have never yet examined any gneiss without finding good evidence that it was part of a stratified series. The doubts that have arisen have related to formations of granite, syenyte, dioryte, granulyte, which rocks are known to be sometimes of igneous origin.

Dr. Lehmann's deductions as to the conversion of dikes and veins by pressure into ambiguous strata, and as to the production of schistose bedding in granulyte and like rocks by plasticity in a confined area, have a very limited application; and no experienced geologist ought to be deceived by such an occurrence.

3. *Geology of Centre County, Pa.;* by E. V. D'INVILLIERS; Appendix A, Extracts from Report to Lyon, Shorb & Co., by J. P. LESLEY; Appendix B, Observations on the Geological formations of Centre County, by A. L. EWING. 464 pp. 8vo, with a colored geological map and other illustrations. Pennsylvania Geological Survey, Report T4.—Mr. D'INVILLIERS describes in this report the coal-measures of Centre County (the central county of Pennsylvania), and also the iron ore (limonite) deposits, the latter partly from investigations by F. Platt, A. S. McCreath, W. G. Platt, J. W. Harden, A. L. Ewing and Professor J. P. Lesley.

The colored geological map shows that the county has its coal-measures on the western border, stretching northeastward; and east of them, nearly in parallel position (determined by flexures of the strata), belts of Lower Silurian limestones (Calciferous, Chazy and Trenton combined) between other belts of Hudson River shales and Upper Silurian, the Devonian coming in on the northwest between these rocks and the Carboniferous. The mines or ore-pits of limonite are situated in the limestone belts in Nittany, Penn's and Brush valleys. Mr. d'Invilliers describes the iron ore as chiefly derived from the oxidation of iron in sandstone beds in the lower part of the limestone formation. The position is said to differ from that of the beds in the Lehigh region and the Great Valley, which have furnished the bulk of the material to the Lehigh and Schuylkill furnaces, these lying either between the Potsdam and the overlying limestone or between the limestone and the overlying Hudson River shales—which shales are damourite schists (hydromica schists) in southeastern Pennsylvania. The iron from some ore deposits in which sulphur occurs, is inferred to be from pyrite, but in most cases, as its purity appears to indicate, from iron in the condition of carbonate. The deposits are very irregularly distributed, and often have limestone in the walls, with much clay and sand (decomposition products) over the ore.

Professor LESLEY, who has long studied the ore beds, speaks of "shafts passing through soft beds of ore and hard ribs of limestone;" of the ore beds in one place "visibly interstratified with the soft clay and solid limestone layers, obeying the strike and dip;" and with regard to a large and typical ore bed, the "Pennsylvania Furnace ore-bank," he observes that the various irregularities in the deposits are owing to chemical changes and consequent changes in bulk in the strata, during the process of oxidation and solution in progress, in which the looser calciferous and ferriferous layers lost their lime constituent, packed their sand and clay, and oxidized and hydrated the iron, thereby excavating caverns, depositing the iron precipitates as ore, and causing settlings and movements of the overlying material, but without much disturbance of the general stratification. "Only such clay-sand-lime-iron deposits as were properly constituted (originally) have been so completely dissolved as to permit the lime to flow off and the iron (oxidized and hydrated) to consolidate into ore." Every stage and phase in the change presented "in other parts of the Appalachian belt from Canada to Alabama may be seen and studied in these ore banks of Pennsylvania Furnace." At one place sixty feet below the sod, "a shaft was sunk forty feet through solid pipe ore, and then limestone." "The tops of pyramids of solid ore are exposed in the floor, and some reach to, or nearly to, the sod above."

Professor EWING states that the "formation No. II," with which the ore deposits are connected, consists below of sandstone and arenaceous limestone, and above of a blue argillaceous limestone; that it is most magnesian or dolomitic below, but that dolomite and limestone succeed each other in many alternating layers. He concludes that the iron of the iron ore was derived from the limestone, in which it had existed as a ferrous carbonate; that part of the limestone affords on analysis one to two per cent of iron, and that this is sufficient for the production of the largest ore beds; that the sand has come from arenaceous limestones, or calcareous sand-rocks rather than from sandstone, and the clay from argillaceous limestones and intercalated shale; that the oxidation of the iron took place *in situ;* that some small amount of transportation by flowing waters may have occurred, as the ferrous carbonate is soluble in carbonated waters. At a quarry near by a body of ore, *Trenton fossils* were found, and not over forty rods off occur the Hudson River shales, so that the ore in that case is within 300 or 400 feet of the top of the Trenton limestone formation; and this ferriferous horizon there extends along the strike of the rocks for about forty rods.

The volume is an especially important contribution to the subject of limonite-beds and limonite making. J. D. D.

4. *Note on the making of Limonite ore beds;* by J. D. Dana.—The results of the Pennsylvania geologists accord well with those the writer has obtained from the study of many of the ore-pits of western New England and the eastern border of New York. As Professor Lesley observes, the conditions, the changes and the results are the same throughout. The source is, in both, chiefly the limestone of the Lower Silurian, along the borders of which are overlying Hudson River slates. For the sake of comparison, the writer here states in brief his own conclusions, reserving details as to facts for another place.

(1) The iron ore deposits occur in the limestone near, or adjoining, either the main belt of slate or schist, or intercalated layers or small flexures of it.

(2) The iron for the ore was derived from the limestone and only to a small extent from the slate.

(3) The iron existed in the limestone as carbonate; probably as a carbonate of calcium and iron, or of calcium, magnesium and iron, or of iron alone (siderite), which compounds were mixed with the dolomite or calcite to make the limestone. Manganese was often also present in the ferriferous carbonate. The massive unaltered iron-carbonate outcrops over portions of the lower part of the ore-pit of Amenia, N. Y., of Ore Hill in Salisbury, and at the Leete ore bed in West Stockbridge, and has been found sparingly in other ore pits; its limit downward is unknown.

(4) The ferriferous limestone, owing to its iron and its porosity, undergoes rapid oxidation and decay. The iron-carbonate, because of its compactness, oxidizes slowly at surface and in its rifts; yet exposure to the weather for two years suffices to make the blocks as black externally as the limonite from the oxidation.

(5) The limestone ledges in view about an ore pit are not fair examples of the ferriferous limestone that has afforded the ore. They contain little iron, or none, and resist decay; while the more ferriferous has disappeared through the oxidation process and the dissolving action of passing waters, or all except clay, sand, etc., from its impurities.

(6) The distribution of the more ferriferous limestone in the ordinary limestone is exceedingly irregular, and the passage between the two usually abrupt; it exists here and there in patches, large or small, broad or narrow, deep or shallow, continuous or interrupted. Toward the northern end of the Amenia

ore pit the limestone stratum dipping southward passes beneath the slate that makes the east wall; toward the bottom its place is occupied for a while by ore; then in the same line the limestone stratum exists again in a short eroded ledge, externally rusting; and then, again, beyond the ledge, the ore occupies the place of the limestone.

(7) The great space which is occupied by the ore deposit and which is often 100 feet or more deep, is not commonly a previously made cavern; it was made by the dissolving away and removal of the limestone as the oxidation went forward. Were the iron derived from the slate or schist no large cavity would be formed, because of the great amount of insoluble material in the schist; and the ore, instead of being pure ore often through depths of 40 feet or more, would be mixed with three or four times its weight of clay. Where derived from the slate, the fact is indicated by the amount of intermixed clayey material, if not also by much half decomposed slate or schist in place.

(8) The ore derives its cavernous character and looseness of aggregation *not* from the difference in the atomic volume of the oxide and the iron carbonate, but from the method of its formation out of the ferriferous limestone; it sometimes makes a crust about the limestone and along its fissures, which crust thickens within and finally, in many cases, encloses a small cavity, the contained limestone being removed by solution, unless impurities remain (clay or sand) to occupy it in part; and in the process the cavity sometimes becomes hung with stalactites. Often also there are concentric crusts made within the limestone.

(9) The clay of the ore pit is generally in the position of the slate or limstone from which it was derived, only slipped somewhat out of place over the ore in many cases, owing to the displacements going on in consequence of the oxidation and removal of the limestone, as is well described by Professor Lesley. A limestone layer is sometimes of full thickness at one end and much compressed at the other from the oxidation and decay there in progress and the pressure of overlying material.

(10) The decomposition of the slate has been promoted by the carbonic acid set free in great quantities by the oxidation of the iron; the carbonated water so made carried away the potash and other protoxide bases from the mica and feldspar, and left the clay (hydrated silicate of alumina) with much undecomposed mica.

(11) The slate or schist of the region contains but little pyrite or other iron-bearing materials to add to the ore of the deposit, yet sometimes enough of pyrite to make the miners avoid the ore which lies near the schist wall of the ore-pit because of the amount of sulphur in it.

The above conclusions the writer has deduced from his observations. The view he is disposed to favor as to the origin of the irregular ferriferous areas in the limestone formation is as follows:

The stratigraphical change, in the region, from limestone to slate indicates that a change took place in the era of their formation from limestone-making seas to mud-distribution seas. During the transition from one to the other, iron was washed down from not distant land, in the state of bicarbonate or a salt of an organic acid, over limited areas of the calcareous deposits. These areas so invaded by the iron-solution during the transition epoch, were within interior seas or basins, or marshes, half shut off from the ocean. The calcareous material wherever receiving the iron-bearing waters became changed more or less completely to ferriferous limestone or ferriferous dolomite, or received pure iron-carbonate ; and as such waters would have been very irregularly distributed in the basin or marsh, and of varying amount, the areas so changed should be very irregular in distribution and depth. Where the limestone is in part argillaceous or arenaceous, the conditions here mentioned may have existed through large parts of the era of limestone-making. The fact that the limestone is so largely *magnesian* is good evidence that the condition of a partly confined sea-basin existed at intervals through the era of limestone-making; for the magnesia of concentrated sea waters must have been the source of that of the magnesian limestone or dolomite.

5. *Glacial Studies.* — In volume xxiv of this Journal (p. 146), an abstract was given of a paper by M. F.-A. FOREL on the structure and movement of glaciers, in which the growth of the crystalline grains of which the ice consists was insisted upon as the essential point in their history. The same author has recently published (Bibl. Univ., III, xii, 70, July 15, 1884) a paper in which he discusses from a theoretical standpoint the probable distribution of the temperature within the mass of the ice of a glacier. He commences with considering the effect of a single winter upon a considerable mass of ice, extending from higher to lower altitudes, and which is supposed to be initially at 0°, and he constructs a diagram showing the portion, superficial below but extending to the bed of the glacier higher up, which might be supposed to be cooled below 0° in the course of the winter. A second diagram shows the supposed effect of a single summer, indicating the portion, superficial above but extending to the bed of the glacier lower down, which might be expected to be affected by the summer's heat and thus be brought into a melting condition. Uniting the two diagrams a third is constructed showing, by the partial overlapping of the two portions named, first, a lower part, A, along the glacier bed, unaffected immediately by either winter or summer; then a part, B, lower down, reduced to the melting condition by the summer and which will always remain consequently at 0° ; a corresponding part, C, higher up than A and like B extending partly over it, into which the winter's cold penetrates but which is unaffected by the summer and which may remain below 0° ; finally, a fourth layer, D (entirely superficial), affected both by summer and winter and whose temperature may vary from 0° to considerably below 0°. In a word, the glacier may be

considered as made up of a superficial portion of changeable temperature and a profound portion of constant temperature. As to the probable temperature of the latter portion, the author in considering the upper regions from which the ice descends concludes that the bottom portion may be divided into layers from lower to higher altitudes of temperatures, successively 0°, —1°, —2°, —3° and so on; the final diagram given shows these successive layers divided by horizontal lines (taking in consideration the effect of the earth's interior heat) which the author suggests as the probable distribution of the interior temperature of the ice-mass, and he concludes with the hope that the truth of his theoretical deductions may be tested by experiment.

6. *Sketch of the Geological History of Lake Lahontan*, by ISRAEL C. RUSSELL.—From the third Annual Report of the Director of the U. S. Geological Survey. This important memoir, now issued as a separate paper, has been noticed in the preceding volume of this Journal (p. 67). It is illustrated by a map, engraved plates, and two fine heliotype plates, one of a remarkable group of the crystals of the pseudomorph named by King "thinolite."

7. *Geologische Briefe aus America an Se. Excellenz Herrn Dr. H. von Dechen.*—These letters by the German mineralogist, Professor vom Rath, contain some of the results of his observations during a recent journey, extending over about a year, through the United States and Mexico. They are marked by the same keenness of observation and vividness of description which characterize the writings of the same author from Sicily, Syria, Palestine and other countries. Some of the localities spoken of in the letters are Colorado, especially the region about Pike's Peak, Virginia City and Nevada, the Yellowstone Park, and Mexico, including Pachuca, Cordova, Zacatecas and Guanaxuato. When in Mexico he ascended nearly to the summit of Popocatepetl and the account of this trip is full of interest; he also visited the locality at which tridymite was first found in Mexico by Castillo, and gives some valuable notes about it. A list is given, with explanatory remarks, of the many fine and rare minerals found in the neighborhood of Guanaxuato.

8. *On the Composition of Herderite*; by J. B. MACKINTOSH. (Communicated in a letter dated Oct. 14.)—In regard to the question as to whether the loss on the ignition of herderite is due, as claimed by Winkler (see October number), to the presence of water and not fluorine, I have proved to my own satisfaction that fluorine is present by etching glass; and I am inclined to think that the cause of the loss in weight on ignition is due to the loss of fluorine, it being replaced by oxygen. Although I have not made any quantitative experiments to test the truth of this assumption, yet by comparing the relative etching power of the herderite before and after strong and prolonged ignition, I am satisfied that such a loss of fluorine actually takes place. In one case when I ignited a portion, finally fusing it until it had lost

6·03 per cent in weight, and testing the pulverized residue for fluorine, I could not succeed in etching glass perceptibly, while an equal amount of herderite under the same conditions rendered the glass rough to the touch, besides being very plainly visible at the etched spot. The theoretical loss, assuming that all the fluorine is replaced by oxygen, taking the formula deduced from my analysis as correct, would be 6·75, which is near the figures found by Dr. Winkler. I find, however, that it is very difficult to increase the amount of loss after the first heating. Probably because an enamel is formed on the surface, which prevents the further action of the air and aqueous vapor.

9. *Stibnite from Japan.* — A short paper was recently read (June 17, 1884) before the "Gesellschaft naturforschender Freunde" at Berlin, by Mr. Wada of Tokio, on some Japanese minerals, viz: on pyrite, chalcopyrite, stibnite, topaz and others. In regard to the magnificent crystallized stibnite of Japan, he remarks that the true locality is the antimony mines at Ichinokawa, in the town Ojoin-mura near Saijo, Province Iyo, Island Shikoku. The locality given in the article on page 215, vol. xxvi, of this Journal, is consequently to be corrected; as explained by Mr. Wada, "Kosang" in Japanese means "mine," "Jaegimeken Kannaizu" means "Chart of (the district) Jaegime, or better, Jaechime."

10. *Flora Brasiliensis*, fasc. XCIII.—This makes the larger portion of vol. vi, part 3, contains the tribes of *Compositæ* from the *Helianthoideæ* to the "*Ligulatæ*" (a new name for the *Liguliflorœ* or *Cichoriaceæ*), and so completes Mr. Baker's task in elaborating the *Compositæ* of the Brazilian empire. A large piece of work, to all appearance carefully done.

The great Brazilian region seems to hold its normal quota of *Compositæ*, namely, the tenth part of the Phanerogamia. According to the reckoning, it has 1280 species (the naturalized weeds included), in 150 genera: not so rich as North America, in which we count 237 genera and over 1600 species. In character the Brazilian representatives of the order differ almost as widely from those of North America as from those of the Old World. This prominently appears in the statement that more than one-third part of the species belong to the three genera *Vernonia*, *Eupatorium* and *Baccharis*, and that the genus next in size is *Mikania*. Thus *Eupatoriaceæ* have a prominence to which there is no parallel. All these genera indeed are fairly represented in North America, but only one of them in Europe, and that very scantily. *Vernoniaceæ* may be said to take the lead, having 24 genera and 289 species; in North America, only 3 genera and 10 species. *Eupatoriaceæ* have fewer (17) genera, but 335 species; in North America 15 genera and 111 species. Then come the *Helianthoideæ* with 40 genera but only 221 species, which falls below the North American 64 genera and 337 species; and *Asteroideæ*, with 14 genera and 183 species; while North America has 33 genera and 462 species. The

Mutisiaceæ, almost all American, are very prominent in Brazil, 18 genera and 99 species. The *Inuloideæ*, a weak tribe in America, with 13 genera and 40 species in Brazil, holds there about the same rank as in North America. The meagre tribes are the *Senecionideæ* (only 3 genera and 58 species), *Helenioideæ* (only 9 genera and 30 species, while North America has 43 genera and 214 species), and especially those largely Old World groups, *Cichoriaceæ*, with only 4 genera and 14 species; *Anthemideæ*, with only 4 genera and 6 species, and two of these Old World weeds; and above all *Cynaroideæ*, of which there is only, a single indigenous species, a *Centaurea*. The *Compositæ* of this flora are illustrated by 210 plates. A. G.

11. *Trilisa* is the name of Cassini's genus; not *Trilisia* as it is printed in the Synoptical Flora of North America, page 113. In the conjectural etymology of this name, Wittstein was unwittingly followed. But the name is evidently an anagram of *Liatris* (from which the genus was severed), as my old friend Mr. Charles Wright points out. A. G.

12. FILIPO PARLATORE, *Flora Italiana, continuata da Teodoro Caruel*. Vol. vi, parte prima. pp. 336, 8vo. Florence: September, 1884.—It is a great satisfaction that the Flora Italiana which, after the fifth volume was arrested by the death of Parlatore, is now continued by the most capable of Italian botanists, Professor Caruel. The task is to be lightened by the coöperation of two or three of his compatriots. The present volume takes up the Corolliflorous Gamopetalæ, and this part contains *Globulariaceæ*, *Lamiaceæ*, and *Verbenaceæ*, not quite finishing the latter. Generic and specific characters are in Latin. These are strictly *characters* or diagnoses; and, after the synonymy, which is in Latin, all needful particulars follow in Italian. Among them a detailed description of almost every species, not rarely filling a page, so that the species average hardly one to a page. The work, with all its (quite too great) amplitude, now bids fair to be worthily completed. A. G.

13. *The Agricultural Grasses of the United States;* by GEORGE VASEY, Botanist of the Department of Agriculture. Washington, Agricultural Department, 1884.—In this compact octavo volume Dr. Vasey, who has long and diligently studied the Grasses, provides a manual for popular use, which seems well adapted to its purpose. He gives descriptions, both fairly readable and fairly scientific, of all the agriculturally important grasses of the country, and some others;—through which, aided by the 120 tolerably good plates, the cultivator and stock-raiser may get to know the principal kinds with which they have to do. An essay on the Chemical Composition of American Grasses, by Clifford Richardson, assistant chemist of the department, is included in this handy volume. A. G.

14. *Descriptive Catalogue of the North American Hepaticæ, North of Mexico;* by LUCIEN M. UNDERWOOD, Ph.D. Separate issue from the *Bulletin of the Illinois State Laboratory*. Vol. II,

pp. 133, 8vo.—A publication like this, which begins with a good bibliography and ends with a good index, might at least have a title-page and a date. Moreover, it deserves a less modest title than that of a descriptive catalogue; for it is really a synopsis of the North American Hepaticæ, with generic and specific characters well worked out. The typography and the whole style are excellent. Here, at length, we have good provision for the popular study of our Hepaticæ, and a foundation for the more elaborate work which the author will undertake. We append the last words of the "prefatory note."

"No attempt has been made to publish new species, the writer believing that too many have already been described from insufficient data, and considering it far more necessary to set in order those already published.

"It is hoped that persons receiving this work will aid the further and critical study of this group by communicating specimens of all the forms found in their own localities." A. G.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Heliometer determinations of Stellar Parallax in the Southern Hemisphere;* by DAVID GILL and W. L. ELKIN; from the Memoirs of the Royal Astronomical Society, vol. xlviii.—Dr. Gill, shortly after his appointment as Astronomer Royal at the Cape of Good Hope, acquired by purchase from Earl Crawford the four inch heliometer which Dr. Gill had used in observing, for the solar parallax, the opposition of Juno at Mauritius in 1874 and of Mars at Ascension Island in 1877. Dr. Elkin joined Dr. Gill at the Cape, and together they observed between July, 1881, and May, 1883, upon a carefully arranged program nine stars for parallax. The following table contains their final results:

		Parallax.	Probable Error.	Mag. of Comp. Stars.
α Centauri........	Gill and Elkin,	+0″·75	±0″·01	7·6
Sirius.............	" "	+ ·38	·01	7·5
ϵ Indi.............	" "	+ ·22	·03	7½
Lacaille 9352.....	Gill,	+ ·28	·02	7·6
o_2 Eridani........	"	+ ·166	·018	6·4
β Centauri	"	— ·018	·019	7
ζ Tucanæ	Elkin,	+ ·06	·019	7½
e Eridani	"	+ .14	·020	6·4
Canopus.........	"	+ ·03	·030	8

One of the principal difficulties in the use of the heliometer lies in the difficulty of determining, under varying conditions of temperature, the values of the scale divisions of the instruments. In the large distances measured by the heliometer, these values must be determined with accuracy at the time of each observation. The measurements by Drs. Gill and Elkin upon the star whose parallax was to be determined were those of the distances of the star from two stars situated as nearly as possible symmetrically on opposite sides of the principal star. The distances of these two stars from each other being regarded as constant, the scale values become at once determinate. Four couples of stars were used in the measures upon α Centauri, and two couples in those upon Sirius and upon ϵ Indi.

These results have been of such value that the British Government has ordered for Dr. Gill the construction of a seven-inch heliometer by Messrs. Repsolds. It is proposed to use this instrument at the Cape Observatory in the determination of stellar parallaxes. H. A. N.

2. *The Materials of Engineering*, in three parts. Part III. Non-ferrous metals and alloys, by R. H. THURSTON. 575 pp. 8vo. New York, 1884 (John Wiley & Sons).—A very large amount of material has been brought together in this volume. It opens with a chapter on the history and properties of the metals and their alloys, and then goes on to the special discussion of the non-ferrous metals to which the book is devoted, namely copper, tin, zinc, lead, antimony, bismuth, nickel and others; also the alloys, as the bronzes, the brasses, the kalchoids and miscellaneous alloys. The latter half is devoted to the discussion of the strength and elasticity of the metals and alloys that have been mentioned, the conditions upon which their strength depends, and the mechanical treatment of the metals and their alloys. The tables in which the various elements are arranged number nearly one hundred, and they are accompanied by numerous diagrams.

3. *A Treatise on the Adjustment of Observations, with applications to Geodetic work and other measures of Precision*, by T. W. WRIGHT. 437 pp. 8vo. New York, 1884 (D. Van Nostrand). —This is a practical treatise giving a sytematic account of the method of adjusting observations founded on the principle of the mean, with a discussion of the applications especially to geodetic and astronomical work. Numerous examples and illustrations taken chiefly from American sources add to the value of the work. The principal topics discussed are: the law of error, the adjustment of direct observations of one unknown, adjustment of indirect observations, of condition observations, application to the adjustment of triangulation, to base-line measurements, to leveling, and so on.

4. *Meeting of the International Congress at Washington.*—At the meeting of the International Congress recently held at Washington, and at which delegates from twenty-two nations were present, some very important decisions were reached. In the first place, by an almost unanimous vote, the meridian of Greenwich was adopted as the prime meridian for the world; only San Domingo voted in the negative while France and Brazil refrained from voting at all. In the second place, it was voted that longitudes should be reckoned east (+) and west (—) of of Greenwich. Finally, it was proposed to adopt a universal day for certain purposes other than local, this universal day to be a mean solar day, to begin for all the world at the moment of mean midnight of the initial meridian, coinciding with the beginning of the civil day and date of that meridian, and to be counted from zero up to twenty-four hours.

5. *Meeting of the National Academy of Sciences at Newport, R. I., October* 14, 1884.—The following are the titles of the papers entered to be read:

On the theory of atomic volumes: by Wolcott Gibbs.
On the complex inorganic acids: by Wolcott Gibbs.
Notice of Muybridge's experiments on the motions of animals by instantaneous photography: by Fairman Rogers.
Report on meridian work at Karlsruhe: by W. Valentiner.
On the Algebra of logic: by C. S. Peirce.
On the temperature of the Lunar surface: by S. P. Langley.
Notice of Grant's difference engine: by Fairman Rogers.
On Gravitation survey: by C. S. Peirce.
On minimum differences of sensibility: by C. S. Peirce and J. Jastrow.
Researches on Ptolemy's star-catalogue: by C. H. F. Peters.
On the operations of the United States Geological survey: by J. W. Powell.
The motion of Hyperion: by Asaph Hall.
Remarks on the civilization of the native peoples of America: by E. B. Tylor.
Some results of the exploration of the deep sea beneath the Gulf Stream, by the U. S. Fish Commission steamer "Albatross" during the past summer: by A. E. Verrill.
Recent progress in explosives: by H. L. Abbot.
On the methods of eastern archery: by Edw. S. Morse.
On the thinolite of Lake Lahontan: by E. S. Dana.
On the Mesozoic coals of the Northwest: by R. Pumpelly.
On the work of the Northern Transcontinental survey: by R. Pumpelly.
On an experimental composite photograph of the members of the Academy: by R. Pumpelly.
The grasses mechanically injurious to live stock: by Wm. H. Brewer.
On the Columella auris of the Pelycosauria: by E. D. Cope.
The brain of Asellus and of the eyeless form Cecidotæa: by A. S. Packard.

6. *French Academy of Sciences.* — Professor James Hall has been elected member of the French Academy in the place of the late Dr. J. Lawrence Smith.

7. *The Young Mineralogist and Antiquarian.* —This is the title of a small monthly paper published by T. H. Wise at Wheaton, DuPage County, Illinois, in the interests of mineralogists.

Notices are deferred of the following works:

A Treatise on Ore Deposits, by J. A. Phillips, 652 pp. 8vo. London, 1884 (Macmillan & Co.).

The Reptiles and Batrachians of North America, by S. Garman. Memoirs of the Mus. Comp. Zool., vol. viii, No. 3. 186 pp. 4to, with 10 plates. Published by permission of the Kentucky Geological Survey.

Description of the Coal Flora of the Carboniferous formation in Pennsylvania and throughout the United States, by L. Lesquereux, vol. iii, 8vo. Harrisburg, 1884, Pennsylvania Geol. Survey, Report P.

Ceratiocaridæ from the Upper Devonian in Warren County, by C. E. Beecher; and Eurypteridæ from the Lower Productive Coal Measures in Beaver Co., by James Hall. Pennsylvania Geol. Survey, Report PPP.

The Deposition of Ores, by J. S. Newberry.

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[THIRD SERIES.]

ART. XLVIII.—*The Distribution and Origin of Drumlins*; by W. M. DAVIS.

The place of Drumlins in a geographic classification—Terminology—General Description—Distribution—Origin.

A CLASSIFICATION of geographic forms may be based first on general and special peculiarities of origin or structure, and second on degree of development by erosion. One could then group together plains, plateaus and their derivative forms under a name that would denote their formation from widespread horizontal layers; and this group could then be further divided according to the composition of the layers, as ordinary fragmental or calcareous strata of subaqueous deposit; as wind-carried dust deposits: as lava flows of igneous rock fed from below; as ice and snow fields of igneous rock from above: and finally as salt plains, the residue of evaporated lakes. All of these subdivisions could be again arranged according to their elevation and age, that is according to their geographic evolution under the destructive processes of time; there would thus be the new low plains, like those of Buenos Aires, still retaining their embryonic features; the adolescent plateaux in our west, of precocious development into forms of deeply incised drainage; the open, broken country of Kentucky, a matured derivative from an old plateau; the expanse of Central Russia, base-level plains of denudation that have returned in their second childhood to the nearly featureless forms of their youth; and so with many other examples.

A more complex group could include regions of disordered structure, characteristic of mountain ranges, but of very difficult subdivision. Here again it is of much importance to recognize the stage of destructive development, in order to mark the contrast between the new, still high and lake-bearing ranges like the Alps; the old, degraded and well-drained mountains like the Appalachians; and the low lands of denudation to which some of the older mountains have been reduced. A third group could bring together all intrusive igneous rocks such as dykes, necks, sheets (laccoliths), and masses; and a fourth would contain all local accumulations, where materials are heaped up on a relatively small base, as volcanic cones of ashes and lavas; æolian drifts, like sand dunes; and glacial drifts, such as moraines, drumlins and kames, which bring us to the special geographic form to be considered here.

It will be perceived that this grouping does not provide a definite place for topographic features of complicated history; it would be difficult, for example, to assign a place for the curved trap-ridges in our Triassic formations. This difficulty is inherent, for in the blending of inorganic forms we are not limited to crossing only between closely related forms as in the organic world; crossing, or double control of form occurs here even between the first structural divisions. Such blending will greatly complicate the resulting forms, and consequently only the simpler or more typical ones are here mentioned. A second cause of complication is found in the renewal of the cycle of development after a certain progress has already been attained; as is the case with polygenetic mountains, or with plains that have stood at different altitudes, like those of our west. But all these difficulties are outweighed by the increased attention and appreciation that physical geography gains when the origin and evolution of geographic forms are duly considered. Their meaning, individuality, and relations are then perceived with a clearness not otherwise attainable. As an illustration of a persistent form it is proposed to describe a kind or genus of smoothly rounded hills of glacial drift, that may be called drumlins. They belong among those elevations made by local accumulation of material by glacial action, on a foundation of other origin; they differ partly in structure and very clearly in form from other glacial deposits; being of relatively recent origin their constructional shape is still preserved, unless where cut by sea-shore waves or large streams, so that their evolution by erosion need not yet be discussed. Their name should be regarded rather as generic than as specific, for it will be shown that hills of somewhat varied form may be fairly included under this term.

TERMINOLOGY.—*Drumlin;* M. H. Close, Notes on the general glaciation of Ireland; read in 1866; Journ. Roy. Geol. Soc. Ireland, i, 207. A word of Irish derivation, meaning a long rounded hill. Most of the following terms are essentially synonymous with it, although some have a more specific meaning.

Parallel ridges; Sir James Hall, Trans. Roy. Soc. Edinb., 1815, vii, 169.

Drums and *Sow-backs* of Scotland; J. Geikie, Great Ice Age, 1877, 13, 76.

Parallel ridges; N. S. Shaler, Proc. Bost. Soc. Nat. Hist., 1870, xi, 27.

Lenticular hills; C. H. Hitchcock, id., 1876, xix, 63. These two papers refer to hills of more oval form than those of Ireland.

Whalebacks in New Brunswick; G. F. Matthew, Geol. Survey Canada, 1877–78, 12EE. These are not clearly separated from hills of stratified gravel.

Parallel drift-hills; L. Johnson, Trans. N. Y. Acad. Sci., i, 1882.

Mammillary or Elliptical hills; T. C. Chamberlin, Geol. Wisconsin, 1883, i, 283. Some of these have an almost circular base.

Of these several terms, drumlin appears by far the best in being a name, not a description; in having in English at least no other meaning than the technical one here adopted; and in having been proposed by the author who first gave a sufficient clue to the origin of these hills. It does not seem worth while to coin a word, as botanists and zoölogists are forced to do, for already a number of local names from various languages have come into general use in geography, as pampa, selva, steppe, tundra, atoll, delta, mesa, cañon, moraine; and drumlin may be well added to the list. Drumlins, using the term in its general sense, may be specifically qualified as long, oval or round.

General description.—Drumlins are hills composed of compact, unstratified glacial drift or till; their form is usually elongate or oval, with a ratio of horizontal axes varying from 6 : 1 to 1 : 1; the longer axis is parallel to former local glacial motion, as shown by neighboring striation or transportation of bowlders; the profile is generally smoothly arched and commonly almost symmetrical; terminal slopes, 3° to 10°; lateral slopes, 10° to 20°; length, one-eighth to two or more miles; height, 20 to 250 feet above base. The general uniformity of outline in any single region is very noticeable; indeed the view from the summit of a commanding drumlin, in the center of a group, shows as characteristic a landscape as that seen in looking from the Puy de Dôme over the extinct volcanoes of

Auvergne. Moreover, the control that drumlins exercise over the laying out of roads and the division of property is so complete in districts where they abound, that it is the rule to find roads, fields, gardens and even houses oriented in obedience to the march of the old ice invasion. About Boston, there are hundreds of dwellings whose walls thus stand in close parallelism with the glacial scratches on the bed-rock beneath them. In a recent number of *Science*, I have given several sketches of these drift-hills.

Distribution.—The absence of drumlins in non-glaciated regions confirms the evidence that gives them a directly glacial origin. When found, they occur either scattered about without apparent system, or crowded together in groups. The most extensive group of which I have a map is in northwestern Ireland, the district described by Kinahan and Close in their paper on the General Glaciation of Iar-Connaught, Dublin, 1872. The direction of neighboring glacial striæ is shown by arrows, which although not all parallel to one another, are strikingly parallel to the nearest drift ridges. These long drumlins "consist of stiff unstratified bowlder clay, containing well blunted and scratched stones and blocks; they have been most unquestionably formed by the rock-scoring streams [of ice], since they are, with very rare accidental exceptions, always parallel to the striæ near them" (op. cit., p. 6). They occur plentifully elsewhere in Ireland (Close), and in Scotland (A. and J. Geikie), and are well shown on some of the shaded one-inch maps of the Ordnance survey; but I have not been able to identify them satisfactorily in descriptions of the drift of Scandinavia, Germany or Switzerland. Erdmann's "Exposé des formations quaternaires de la Suede" (Stockholm, 1868) may perhaps refer to drumlins on p. 24 . . . "dans les plaines, ces masses de gravier (bowlder clay) s'élèvent en nombre considérable des couches d'argile environnantes, sous forme de collines plus ou moin grandes." Desor did not include them as characteristic features of his "Paysage morainique" (Paris, 1875). If occurring on the continent, they have not received the attention they deserve.

On this side of the Atlantic, they are common in many States. A fine group has been found in southeastern New Hampshire and the adjoining part of Massachusetts, which is represented on the geological atlas of the former State (1878). The group about Boston has been well described by Mr. Warren Upham (Proc. Bost. Soc. Nat. Hist., 1879, xx, 223). Corey's hill, the most northern of the group in the town of Brookline, is one of the best examples, and is well seen from the city looking westward up the Back Bay. A fine series of drumlins stretches from about Spencer, Mass., to Pomfret, Conn., but the detailed study that it would well repay has not yet been attempted. Members of this series occur near Charlton station, Boston and Albany railroad, with their bases at an elevation of 900 feet above sea-level, and others stand still higher. The portion of the group in Connecticut is described by Percival as follows. "The district extending north from Hampton, through Abington, Pomfret and Woodstock, is characterized by a series of very smoothly rounded, detached hills, in which the rock is usually entirely concealed. These form a striking contrast with the longer and more continuous [rocky] ridges of the adjoining formations" (Geol. Conn., 1842, 256: also 461, 479, 485). Prof. G. H. Stone reports that drumlins of large size, like those about Boston, have not been found in Maine. Western New York, between Syracuse and Rochester presents a surprising number of parallel, north-and-south drift hills, probably familiar to many travelers by rail. Some of them are so long, smooth and even that the country thereabouts has been described as *fluted.* These were long ago described by Prof. Jas. Hall in his Geology of the 4th district of New York (1843); since then they have been strangely neglected until examined by Dr. L. Johnson, who has lately published a paper entitled "The parallel drift-hills of Western New York" (Trans. N. Y. Acad. Sci., 1882, i, 77). Some of the ridges are "two or three miles long, and attain elevations of 100 or 200 feet above the intervening valleys; but the greater number are shorter and steeper. Many of them were, when first cleared of timber, very steep at their north ends, and on their east and west sides; but, with very rare exception, the southern slope is gradual." These and other irregularities of form may require that some of the hills of this region should be separated from drumlins as here defined. In Wisconsin, the drift-hills, as described by Prof. T. C. Chamberlin "are arranged in lines, and their longer axes invariably lie parallel to the movement of the ice. In some localities, especially in Dodge and Jefferson counties, these are mainly replaced by long parallel ridges, sometimes several miles in length, with corresponding linear marshes interspersed. These correspond accurately to the direction of ice motion." (Geol. Wisconsin, 1883, i, 283.) According to Mr. Upham, drumlins are not found in the abundant drift of Minnesota. A few examples are mentioned for Pennsylvania near its western border by Prof. Lewis. (2d Geol. Surv. Pa., Terminal Moraine, 1884, 29, 188.) It is evident enough from this review that the distribution of drumlins is insufficiently known.

Origin.—The earliest discussion of the origin of drumlins that I have found is in Sir James Hall's interesting paper on the Revolutions of the Earth's Surface (Trans. Edinb. Roy. Soc., 1815, vii, 169). After describing the general form and structure of those about Edinboro', he says: "The facts seem to meet the challenge held out by Mr. Playfair in the following passage from his Illustrations of the Huttonian theory, art. 366. 'If there were anywhere a hill, or any large mass composed of broken and shapeless stones, thrown together like rubbish, and neither worked into gravel, nor disposed with any regularity, we must ascribe it to some other cause than the ordinary detritus and wasting away of the land. This however has never yet occurred, and it seems best to wait till the phenomenon is observed before we seek for the explanation of it.' Now it appears to me, that these vast assemblages, in which blocks of every size, and shape, and quality, some sharp, some round, are confusedly scattered through clay, are inexplicable by any diurnal cause, and do call for some particular solution" (p. 174). Sir James consequently decided in favor of earthquake waves as a means of forming drumlins: he recognized that the ridges of compact clay were parallel to one another (p. 177), and to the scratches on the bed rock below (p. 183), and considered vast diluvial waves competent to produce all these effects. Others of the older geologists have since then ascribed drumlins to the rush of diluvial floods; but it is noteworthy that no explanation of drumlins by iceberg action has yet been suggested. These hills indeed offer strong evidence against the sufficiency of that theory.

It is unnecessary here to enter on the evidence that places unstratified drift, with its scratched stones and large subangular bowlders, among the effects of land-ice action. Since it has been generally thus regarded, several suggestions of more detail have been made as to the origin of the peculiar form of drumlins. They have been considered the product of post-glacial erosion acting on a broad sheet of drift by W. Harte (Journ. Roy. Geol. Soc. Ireland, 1867, ii, 30) and Professor Shaler, (l. c.), but this explanation does not account for the remarkable parallelism between drumlins and striæ, and it assumes too great an amount of post-glacial erosion. Several authors, to be mentioned below, regard them as having attained their present form by local accumulation beneath the old ice-sheet, and this seems to me the most fitting suggestion. Prof. C. H. Hitchcock has thought that they may be due to the remodeling of old moraines under a second advance of the ice (Proc. Bost. Soc. Nat. Hist, 1876, xix, 66), and Prof. G. F. Wright has made a similar suggestion. Central New York gives this explanation its best support, for there the hills often stand closely side by side for many miles; but in New England, where the hills are scattered, with numerous and wide spaces between them occupied by insignificant deposits of till, the suggestion is not so-satisfactory. Professor J. D. Dana's description of Round Hill near New Haven (this Journal, 1883, xxvi, 357), would imply that it is a drumlin, although he calls it a kame; he suggests that it was formed by streams plunging down from the surface of the ice through a knot of profound crevasses, and "causing a local deposition of the stones and earth that were in the ice." But the absence of stratified sands and water-worn stones in the hill seem to negative this suggestion; and the occurrence elsewhere of numerous drumlins at high levels, as at Charlton, Mass., requires some other explanation.

The first clear reference to drumlins as directly dependent on glacial action for their form was made by M. H. Close (On the glaciation of the rocks near Dublin, Journ. Roy. Geol. Soc. Ireland, 1864, i, 3); they are here said to be parallel to the neighboring striæ, and hence like these dependent on the ice-sheet for their present attitude and form. The same conclusion is presented in the paper of 1866, above mentioned, when the name *drumlin* was first specially proposed for them. Still later, when describing the physical geography of the neighborhood of Dublin (id., v, 1877, 49), Close writes: "It is perfectly certain that it must have been the rock-scoring agent which produced the bowlder-clay ridges." Besides this, Kinahan and Close, in the pamphlet above named, stated their opinion that drumlins were formed in a way "similar to that by which a stream of water often makes longitudinal ridges of sand in its bed." This is to my mind the best suggestion yet given to account for them.

J. Geikie wrote as follows: "The remarkable linear direction of certain mounds of bowlder clay in some districts of the Lowlands, agreeing as this does with the general bearing of glacial markings of the same localities, induces us to believe that we have here, with certain modifications, the original contour of the till after the superincumbent ice-sheet had disappeared" (On denudation in Scotland since glacial times, Trans. Geol. Soc. Glasgow, 1867, iii, 61); but he believed that these forms may be also in part dependent on marine erosion. In the Great Ice Age (1877, 76), the same author briefly mentioned "the series of long smoothly-rounded banks or drums and sowbacks, which run parallel to the direction taken by the ice," and regarded them as very little modified from their glacial form. They are "produced by the varying direction and unequal pressure of the ice-sheet," and are "the glacial counterparts of those broad banks of silt and sand that form here and there upon the beds of rivers." Dr. L. Johnson says that he accepts Geikie's explanation and applies it to the New York ridges which were "formed underneath the glaciers by alternations of lateral pressure" (l. c. 1882); but this form of statement does not commend itself so highly as the preceding.

In this country, Professor C. H. Hitchcock and Mr. Warren Upham, while engaged on the geological survey of New Hampshire, were the first to discover the parallelism between glacial motion and the axes of drumlins in 1875; they concluded that "the accumulation of these hills and slopes seems to have been by slow and long-continued addition of material to their surface, the mass remaining nearly stationary from the beginning of its deposition. Obviously this was the case with the lenticular slopes gathered behind the shelter of higher ledgy hills or upon their opposite sides" (Geol. N. H., 1878, iii, 308). A little later, Upham wrote: "Although we do not discover the cause of the peculiar distribution of these hills, it seems quite certain that they were accumulated and moulded in their lenticular form beneath the ice" (Proc. Boston Soc. Nat. Hist., 1879, xx, 223). Professor Chamberlin's observations led him to a similar conclusion: "The drift presents some peculiar tendencies to aggregation. . . . . A special tendency is observed over certain considerable areas lying not far from the Kettle moraine, to accumulate in mammillary or elliptical or elongated hills of smooth flowing outline" (Geol. Wisc., 1883, i, 283); and again, after repeating this opinion, it is suggested "that a deeply hidden boss of rock is usually and perhaps universally, the determining cause of these peculiar accumulations" (U. S. Geol. Survey, 3d Ann. Rep., 1883, 306).

In reviewing these explanations and the observations on which they are based, together with such evidence as my own studies have discovered, the conclusion that drumlins should be compared to sand banks in rivers appears the most satisfactory yet advanced. They seem to be masses of unstratified drift slowly and locally accumulated under the irregularly moving ice-sheet, where more material was brought than could be carried away. The evidence for the sub-glacial growth of drumlins may be summarized as follows: The scratched stones in the mass of bowlder-clay show a differential motion of its several parts as they were scraped and rubbed along from a generally northern source, and gradually accumulated where now found.* The compactness of the mass suggests an origin under heavy pressure. The attitude of the hills demonstrates a close dependence on the motion of the ice-sheet. The superposition of kames on their flanks proves that their present form was essentially completed when they were uncovered by the ice-sheet; and the small change of form in the kames shows that the drumlins also can have suffered very little from post-glacial erosion;* the faint channeling of their smooth slopes by rain measures the small amount of denudation that they have suffered since they were made. It must therefore be concluded that they were finished closely as we now see them when the ice melted away, and hence that they were of sub-glacial construction.

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* A paper by Mr. Hugh Miller, read at the recent Montreal meeting of the British Association, gave several admirable illustrations of this "fluxion structure in till."

The supposed manner of accumulation of drumlins may be briefly sketched. It is well-known that a stream of running water will at one point carry along silt and sand that must be dropped a little farther on where the current slackens; and the bank thus begun grows slowly in a form of least resistance, attaining a maximum size when its increase of volume has so far diminished the cross-section of the stream and consequently increased the velocity, that no more detritus can be dropped there; but even then, one end may be worn away while the other grows; the adjustment of velocity to channel is not permanent. The motion of a glacial sheet has been justly compared to that of a broad river. The comparison may be extended so as to liken the active head waters of a stream to the presumably fast-moving part of the ice-sheet near its source or center of dispersion, where the greatest erosion generally takes place. The delta of a river corresponds to the thinner and slower-moving marginal area of an ice-sheet, where drift brought from elsewhere is quietly and evenly deposited as in Minnesota, and where erosion is relatively weak.† A still further agreement is discovered in comparing the drumlins and sandbanks, found in the middle course of the molten and solid streams, as suggested by the several authors quoted above. In view of the irregularity of the surface on which the ice-sheet moved, and of the greater weakness of some rocks than others, we must suppose an irregular velocity in the motion of the ice and an unequal distribution of the rubbish beneath it. If the faster motion at one place cause an excess of erosion there, the slower motion at another place may bring about an excess of deposition. This difference of action is known to prevail between the central and marginal parts of glaciated areas; and the local accumulation of drumlins in an intermediate region gives a smaller example of these two parts played by the ice. If the causes of the irregular motion of the ice lie in the general form of the country, the location of faster and slower currents will be relatively permanent; the districts of faster currents would be found where the greatest volume of ice is allowed to pass, and some of the points of retardation may be the seats of long continued drumlin growth. The drumlins thus begun will depend less on the immediately local form of the ground than on the topography of a more considerable district, and hence we need not suppose every drumlin to have begun its growth upon a knob of rock, although the beginning of many hills may have been thus determined. Once begun, the drumlins will go on increasing in size, as long as deposition exceeds erosion, always maintaining an arched form of least resistance, until a maximum size is reached, or until the ice melts away: and in their growth they will approach the form to which rough, rocky hills would be reduced by the reverse process of erosion, if time enough were allowed. Under unending glaciation, the whole surface must be rubbed down smooth.

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* This assumes a point on which there is now a tolerably general agreement: namely, that kames were formed close by the front of the melting and retreating ice.

† The recent history of this comparison is given in my paper on Glacial Erosion, Proc. Bost. Soc. Nat Hist., 1882, xxii, 33.

I am well aware that it is venturesome to go so far as this in theory before all the facts are in. When more is known of the distribution of drumlins, the suggestions here given may have to be abandoned; but it is nevertheless impossible to resist theorizing, and perhaps the collection of facts, *pro* and *contra*, may be hastened by a little venture in speculation. It is very desirable that the regions occupied by drumlins should be more closely studied; when this is done, it may be possible to give in more definite terms the reasons for their choice of attitude, and additional chapters in their history may then be written.

Cambridge, Mass., October, 1884.

ART. XLIX.—*Geological Relations and Genesis of the Specular Iron-Ores of Santiago de Cuba*; by JAMES P. KIMBALL.

FOR a distance of at least some 20 miles east of the longitude of the bay of Santiago de Cuba, the Sierra Maestra, or coast-range, maintains a height of about 4240 feet, as barometrically measured by Mr. Emile Sarlabous, vice French Consul, at the point on its crest well known as Gran Piedra. On local maps of the Province of Santiago, this point is laid down as 5·69 miles from the coast of the Caribbean Sea, which is generally parallel to the crest of the range. The great outlier or escarpment of Gran Piedra, according to the same authority, presents the same lithological features as its lower foot-hills, namely—a coarsely crystalline syenyte of eruptive origin. Wherever this has come under my own observation, within the expanse of the lower foot-hills, it is penetrated by very numerous dykes of diorvte.

From the overflow of similar dykes, the upper immediate flank of the Sierra Maestra and middle foot-hills are covered with a mantle of the same trappean rock. The maximum thickness of this mantle I estimate to be about 2000 feet, corresponding to an altitude of about 3800 feet.

The Sierra Maestra is the south (front or coastward) range, and last elevated, as well as the longest, of a series of successively elevated ranges, together forming the broad belt of mountain plateau, stretching nearly to the north coast, and running out to a point at Cape Maysi. West of the bay of Santiago, a lower range, of still subsequent elevation, forms the coast-range of the southern peninsula. This range is locally known as the Sierra de Cobre, although on general maps not distinguished from the Sierra Maestra.

Reference will presently be made to the more special lithological features of both ranges, within the limited scope of my observation. Occasion is here suggested to note as a significant fact in relation to the vulcanism of the Sierra Maestra, the family relation of the two types of eruptive rocks entering into the structure of at least the base and south flank of this range. The significance of this fact, in connection with others that will be noticed, appears to be that the overweighting of the syenyte mass along an inherent line of least resistance, corresponding to the margin of the sub-oceanic basin of the Caribbean Sea, has been followed first by depression, attended with re-melting of the base of the mass; and afterward by elevation. This elevation, it will be shown, has taken place by successive stages. The final, if not the concurrent, result of such oscillations of level has been to inject the molten magma in the form of dioryte through fissures incidental to elevation.

The diorytic mantle thins off toward the coast, in part by erosion, while the lower ranges of foot-hills are completely denuded of dioryte, if ever enveloped.

The immediate coast presents a remarkable development of coral rock, or coral limestone, in three terraces, of which the upper is about 350 feet above the sea. The second terrace is at an altitude of about 175 feet, and the present shore, a plateau of comparatively recent elevation, about 14 feet above tide. These terraces mark successive elevations of the Sierra Maestra range. These stages of elevation were in direct, but probably remote, succession with other elevations which I shall show to be indicated by traces of more ancient corallines (coral formations) about two miles still farther back from the present coast.

The last terrace, or that of the present shore, falls away vertically into deep water, soundings at the mouth of the Carpintero, 150 feet off shore, giving a depth of 165 feet. It retains to a remarkable degree the structure of solid reef, studded with distinct forms of coral, and is strewn with fragments of coral, rounded by the waves, but in good preservation, and numbering a large variety of species.

The two older terraces retain little or nothing of corallum structure, but are thoroughly consolidated, indurated and crystalline. As an effect of the action of the waves in former periods, they still present mural escarpments seaward, with a talus at the base of each from weathering, and from clefts produced by the wedging effect of roots of trees.

The upper terrace reposes directly on the syenyte, and east of the Carpintero river (Juraguacito) forms the immediate coast. The base of the two lower terraces is concealed.

The bay of Santiago corresponds to an original recession of the coast, the eastern limit of which was the mouth of the river just mentioned. This recession was once filled out with coral formation. Subsequent to the final elevation of the Sierra Maestra, the coralline was eroded into the present land-locked form of the bay with the preservation of a wide margin of this calcareous rock. Both shores have been excavated from corallines, of which those already noticed are the more recent and easily distinguished. These present a bold front to the bay. The old Morra fortress is on the second and third terraces, numbered in inverse order of succession. Earlier corallines are less easily identified with what study I have been able to give to the region. The elevation of the Sierra de Cobre, the eastern end of which range faces the bay, seems to have resulted in the final elevation of the coralline area. The succeeding excavation of the bay has been effected with but little aid from existing streams, the present drainage of the mountain plateau of the Sierra Maestra and back ranges being to the east and west of it.

The bay of Guantanamo, 51 miles east and about three times the area of the bay of Santiago, possesses so many obvious points of resemblance to the latter, including littoral, topographical and hydrographical relations, as to suggest in both cases also similar geological relations. Mr. Sarlabous informs me that the margin of the larger bay, like that of its twin, is of coral-rock.

In the vicinity of Guantanamo Bay and thence eastward, the dioryte mantle appears from the sea to envelop the crest and the whole southern flank of the Sierra down to the coast. Place is given to this remote observation, confirmed as it is by Mr. Sarlabous.

The Juragua Hills, so-called, are the culmination of the middle ranges of foot-hills of the Sierra, about half way between the bays of Santiago and Guantanamo, or, more closely defined, between the mountain streams, the Carpintero (Juraguacito) and the Daiquri.

Along with a study of some very remarkable deposits of a specular ferric oxide, in course of development by the Juragua Iron Co. (Lim.), for consumption in Pennsylvania, these hills came under my observation in the months of June and July last.

As here distinguished, they consist of two parallel ranges of foot-hills distinct from the immediate south flank of the Sierra Maestra. The first or upper range reaches an elevation of about 2000 feet; the second or lower, of about 1100 feet.

Both ranges are the topographical result of the erosion of the south slope of the Sierra Maestra, within the compass of the dioryte mantle down to the underlying syenyte, and in the case of the lower range, well into the syenyte. The syenyte base of the upper range is occupied by the bed of the Carpintero, and that of the lower range by the Juragua and its east fork—the Benevolencia.

The lower contact of the dioryte mantle with the syenyte base of the Sierra (according, first, to unequal elevation and, second, to subsequent unequal erosion), follows a convoluted line. This contact corresponds, as I believe, to parts of a former coast line, as shown by traces of ancient corallines. These traces are as follows:

1. Isolated bodies of marble without stratification, but with marked prismatic cleavage. These invariably occupy the elevated parts of the contact.
2. Isolated bosses and other bodies of specular and amorphous ferric oxide, only partially dehydrated, which I take to be replacements of ancient corallines. These occupy the lower parts of the contact.

Referring both occurrences to their original relations to the coast, they seem to be relics of bodies of coral rock and of coral reef reposing on the syenyte. These masses became implicated in the igneous overflow, one or more than one, from the north. This is shown by the approximately east and west direction of the longer axes of them all. The upper ones, or those now occurring as marble, were probably of the nature of emerged coralline, while those occurring as ferric oxide, lower in position and farther to the south, were probably of the nature of coral-reef when involved in the eruptive flood. These are found directly back of the lower contact, while the bodies of marble, in a similar relation to the contact, appear to be farther back of it.

The thinning of the dioryte mantle toward the sea is thus seen to have been not altogether the result of its flow, slackening as may be supposed inversely to its mass, but to have been promoted by the extinguishing effect of the sea. The sea seems also to have brought the flow to a stop.

No traces of ancient coral reefs have been observed between the contact, within the area of the still lower syenyte foot-hills, and the emerged corallines of the present coast margin. Yet such corallines may have once existed, and since disappeared by subaerial erosion.

Nor is proof afforded of any former extension of the dioryte mantle below or south of the contact. Diorytic dykes, nevertheless, in great number, penetrate the syenyte on every hand, their frequency becoming less toward the west, as distance increases from the culmination of the Juragua foot-hills. Beyond them, west of the Carpintero, but in line with the second range of foot-hills, or just back of the general course of the contact, the syenyte hills have been wholly denuded of dioryte, the hills themselves becoming gradually degraded toward the bay of Santiago, and exhibiting the extreme effects of weathering decay characteristic of highly crystalline feldspathic rocks in lower latitudes. Remnants of detritus, dioryte and hematite, upon the surface of these hills, attest the former extension of at least a thin development of the dioryte mantle. Unlike the lower syenyte hills of the Juragua group, these hills have not opposed to erosive agencies a great number of ribs or dykes of more enduring trappean rock.

In the absence of remnants of dioryte in place, the presence of specular ore-float in place is equally significant. For all recognized ore-bodies and marble-bodies are encompassed by dioryte, or by products of its weathering, though limited to its lower margin—the ancient littoral, and in part submarine, relations of which are argued as above.

The interesting question now arises whether the diorytic intrusions within what at the period of their vulcanism was a submarine syenitic area, below the level of the habitat of coral life—did not stop short of overflow. That such intrusions may have been limited in upward range by the submerged surface of the syenyte seems indeed probable on general grounds. Hence the erosion of the lower syenyte ranges of hills, three in number, of the Juragua group, may never have involved the disappearance of even a reduced thickness of the dioryte mantle, as compared with its medium (if not minimum) original development immediately back of the present contact. The proposition then is that the present syenyte contact, as far as indicated, was the actual lower limit of the dioryte mantle, as it is in fact at present. This I am inclined to believe.

The several terraces of recent coralline mark, as already indicated, successive, and in chronological order the later, uplifts of the Sierra, in vertical range not less than 500 feet. These, together with the series of corallines of the second line of foot-hills, as recognized by the bodies of hematite and marble, are proofs of a sum of uplifts of not less than 1300 feet.

Obscure traces upon the first range of foot-hills of still more ancient corallines, to which I shall again refer, point to a still more remote succession of uplifts whose vertical range—referred to the latest indicated level of coral formations, some 100 feet below the present shore—may be estimated as about 2300 feet. From the syenyte hills may have disappeared by subaerial erosion intervening corallines, between those of the present coast and the line of ancient, and now metamorphosed, corallines traced along the contact or southern margin of the dioryte mantle.

Dry beds of once powerful streams occupy deep defiles of the foot-hills, further attesting hydrographical changes of such a scope as may be believed to be commensurate to the degree of successive elevations of the Sierra. Such defiles are the arroyos Negro, Caridad, La Plata and Berraco. The dry and nearly filled up Laguna of Berraco, so-called, some fifteen miles east of Santiago Bay, and a few feet above tide, corresponds to a former indentation of the coast at the mouths of what appears to have once been two of the largest streams of the south slope of the coast range.

The syenyte of the lower foot-hills is weathered to a depth as far as yet penetrated by railway cuts. All fresh surfaces thus exposed exhibit its disintegration along divisional planes, with the result of an obliteration of its prismatic structure from jointing. The incomplete exfoliation of prismatic blocks between joints has resulted in the usual rounding of the undecomposed centers in the form of cores. At the surface, where freed from their interstitial products of decay, these appear as outlying bowlders. The weathering of the diorytic dykes which traverse the syenyte in directions of least resistance corresponding to its jointing, is indicated by the passage of their hornblende into epidote and chloritic residuums.

The dioryte also presents toward its lower margin marked phenomena of weathering decay or of metasomatic alteration. These will presently be described as subsidiary results of the process of epigenesis, or course of permutations, by which the calcareous material of implicated bodies of corallines has been replaced by ferric oxide.

The weathering of the upper parts of the dioryte mantle is less obvious. Yet, like all superficial masses of ancient (especially eruptive) basic rocks, it stands for a once more basic aggregate, from which protoxide bases have been largely eliminated in the form of sulphates and of alkaline bicarbonates. The epidotic character of much of the dioryte where least obviously weathered, is one of the proofs of the instability of the hornblende. Again, regarded as a feldspathic aggregate under conditions of extreme exposure to weathering action, all parts of the dioryte must be assumed to represent its effect, however unequal, and insusceptible of measurement without the partial preservation of the original type for comparison. This consideration is one of importance in the present case, because a large source of ferric oxide must be looked for to account for its accumulation, under favorable circumstances of drainage, in the form of the iron-ore bosses along the lower edge of the dioryte mantle, at its contact with the underlying syenyte.

Two series of circumstances have determined the *loci* of these iron-ore bosses, viz: (1) the *loci* on the ancient submarine slope of the syenyte on which coral-reef was reared, or on which coral sediments were piled up by the waves; and (2) subsequent favorable conditions for the supply of ferric oxide to replace lime carbonate as fast as it dissolved under the intermittent action of percolating acidulated waters and of alkaline bicarbonates.

1. Proof of the coralline parentage of the iron-ore bosses is the preservation in nearly all of them of fossil corals, or at least of casts of coral. Such casts are found toward the outer parts of ore-bodies, in what may be called their transition parts. These are in general siliceous from the segregation of silicates. While the lime carbonate of the casts referred to is replaced by ferric oxide, the cells of the corallum are filled out with segregated matter, more or less chloritic from secondary alteration.

The larger bosses, corresponding to coralline masses, exhibit a concentric structure characteristic of segregation by foliation or external deposition. The smaller ones, on the other hand, frequently present the peculiar warped surfaces characteristic of the coral rocks, and such as may be seen on every cliff or detached mass of coral rock in the terraces along the present coast.

The larger bosses may in a general way be described as lenticular bodies, any section of which is approximately elliptical. The smaller ore-bodies are of irregular shape and suggest a fragmentary relation to the larger ones, especially as they are always found near the larger, and invariably in such relations as would correspond to the superior surfaces of corallines referred to their original relations with their syenyte base.

The position of all the ore-bodies is on the inner or upper side of the syenyte contact, but laterally and terminally surrounded with altered diorytic rocks. This fact, together with the circumstance that their longer axes are approximately parallel to the crest of the Sierra as well as to the present coast, tends to show the parent corallines to have been involved in the igneous flood down the Sierra slope from the overflow of innumerable dykes. The implication of the corallines in the flood of eruptive, was probably attended by elevation of the whole range, including the coast. Subsequent elevations have raised them higher, and further withdrawn the coast. Some of the ore-bodies are penetrated by courses of dioryte, now sometimes represented by chloritic kaolin. These I am disposed to refer to ramifications of the eruptive material in the act of overflow and upheaval.

2. The ore-bodies, whose general position is thus to be defined, occupy the thinning edge of the dioryte mantle. How far its reduced thickness is due to erosion, and how far to its original development, or to the circumstances of its flow, is partially indicated by the degree of erosion which the ore-bodies themselves have undergone. All that have been discovered have been more or less truncated by erosion.

The relation of the marginal region of the dioryte mantle to the great body of the same basic formation back of it, and to the underlying syenyte, and the preservation under conditions of energetic weathering of the syenite in hills in front, are circumstances readily recognized as favorable to metasomatic action along this margin. Underground as well as superficial drainage of both formations must have been directly toward this margin, especially before the present minor topography was sculptured. That the present topography has been wrought subsequent to the formation of the iron-ore masses is clear from the fact of their erosion by the streams, which now follow in part the same marginal region of decayed and decaying rocks.

Unequal elevation or unequal erosion, or probably a combination of both conditions, has served to introduce a series of conditions unfavorable in certain cases to the radical alteration of coralline masses. In such cases the coralline mass occurs in the form of white marble. In attitude and general relations both with the syenyte and dioryte such masses have only certain features in common with the ore-bosses. They have already been described as devoid of stratification, and as strongly characterized by a prismatic cleavage. They all occupy positions in the Juragua Hills toward the summits of the second range, at the base of which the ore-bodies are distributed. Under such circumstance all drainage both from the dioryte and the syenyte is and always has been away from them, and *pari passu* toward the iron-ore bodies. The encasing dioryte exhibits no marked phenomena of weathering. The argument for the limited degree of weathering sustained by this rock under such conditions, it will be noted, is by induction. Replacement of calcareous matter has gone on only at the surface of such bodies as shown by the prevalence of float of ferric oxide remarkably pure, but evidently from small plates or segregations on their sides. Garnetiferous aggregates with considerable proportions of specular and magnetic oxides of iron are the most common products of metasomatism met with on the dioryte summits.

The marble ledges have, however, so many relations in common with the iron-ore bodies, the coralline parentage of which seems to me demonstrated, that they likewise must be referred to a similar primary origin. Their metamorphism or crystallization is due to igneous contact. Their preservation in the metamorphic state without metasomatic alteration, is explained as above by their obvious exclusion from the conditions which have governed the alteration into ferric oxide of other corallines, whose more favorable environment with reference to such an alteration, I now proceed to describe.

Toward the continuous base of the second range of hills the dioryte margin, just back of the contact, has passed into miscellaneous aggregates of a chloritic type. Such are the rocks which immediately encase the ore-bodies. They are soft, rotten and bleached. In color they are of various light shades of green. By further oxidation of ferrous silicates, this coloration has locally given way to darker complexions of red and brown, especially in such as exhibit a notable proportion of free silica, and a dense amorphous consistency. Aggregates of clear crystalline quartz in admixture with magnetic oxide of iron likewise occur, apparently as residual forms of the alteration under local circumstances of basic material originally containing a notable proportion of this oxide.

The syenyte conspicuously outcrops in contact with ore-bodies only in a single instance. This is the south ore-body of East Mine Hill. Here one side and both ends of the ore-boss abut upon the syenyte, which thus forms a *cul-de-sac*. The contact upon the exposed side is occupied by two courses of rotten, aluminous and bleached chlorite in a kaolinized state. These are succeeded by a plate of amorphous siliceous and highly ferriferous material, 3 feet in thickness, within the compass of the ore-body and forming its outer wall. Irregular courses of chloritic and distinctly aluminous material correspond to outer shell-like divisions of the ore-body, due, as I suppose, to the exfoliation of siliceous (insoluble) matter in the process of molecular rearrangement of the mass in the process of segregation and concentration of ferric oxide, attending its replacement of lime carbonate. A part of the siliceous matter thus exfoliated probably represents detrital contents of coralline masses; another part the alteration *in situ* of ramifications or tongues of diorytic eruptive material intruded into frac-

es of the original coralline mass when overwhelmed and
ed.

Courses of chloritic material of the above description encase
lower ends, at least, of all the ore-bosses wherever terminal
ts have been uncovered by excavations. These conform to
general lenticular outline already referred to, and hence
to be referred, as above, to exfoliated insoluble residuums.
ey are similar in type to the intrusions of siliceous material
hin the compass of the ore-bodies. The decomposition of
ke-like ramifications *in situ* is seen to result in a product
istinguishable from the residuums instanced from diorytic
ritus in the parent coralline. This may be supposed to
low from the qualitative identity of such detritus with the
ryte from which it was mainly derived.

The terminal parts of only the lower and more accessible
ls of the ore-bodies have thus far been exposed by excava-
ns at the base of the hills, and just back of the contact,
ere, in the course of its convolutions, this conforms to the
therly course of streams. The longer axes of the ore-bodies
therefore transverse to such parts of the beds of streams as
ve been eroded along the contact. Only where assuming a
gitudinal direction has the contact, for obvious reasons, pre-
ted to erosion the line of least resistance.

The chloritic courses immediately encasing the ore-bosses,
l which have been described as exfoliated residuums, alter-
te with divisions of siliceous ferric oxide. Incomplete quaqua-
sal or rounded dips are thus observed at the lower terminal
rts of ore-bodies. The concentric structure, of which they
the outer manifestation, prevails as far as can be seen within
interior of the less eroded ore-bosses where penetrated by
fts. Hence a divisional structure resembling that of an
ion, and easily mistaken for bedding. The shell-like divis-
s, elsewhere described as transition parts of ore-bosses, give
y inside to massive ore divisionally arranged as above
tanced. The conditions of the central and nether parts
the larger ore-bosses have not yet been brought to light.
e center of the south ore-boss of East Mine Hill appears to
not far away from its eroded surface. The ore is there pre-
nted in massive form and of extraordinary purity.

The larger ore-bodies present all the numerous physical types
specular oxide, besides a variety of phases from unequal
tribution of pyrite and of magnetic and manganic oxides,
d from an unequal degree of hydration. Earthy admixtures
of a chloritic and epidotic type, and thus essentially basic,
fering in this respect from Huronian speculars whose earthy
dency is decidedly acid from segregations of quartz or
m intercalations of jasper. As returned by numerous average

proximate analyses from commercial samplings, exclusive of my own, moisture, in part hygroscopic, is constantly present in percentages of 0·24 to 0·81; silica and insoluble 5 to 10¼; phosphorus 0·009 to 0·065; sulphur 0·045 to 0·248; and iron 61 to 68½.

It is needless here to follow out what may be termed the circular processes of the epigenesis of ferric oxide from basic rocks through the mediation of meteoric waters charged with organic, sulphuric and carbonic acids, and of its preservation under favorable conditions. The replacement of soluble lime carbonate by comparatively insoluble ferric hydrate in the act of peroxidation from ferrous carbonate and from ferrous sulphate, and its concentration under favorable conditions by segregation or as a sediment as the case may be, are common and well known phenomena.

The Clinton so-called fossil-ores of the Upper Silurian areas of the United States afford a familiar example of the replacement of limestone by ferric oxide. The Archean specular ores of the James River of Virginia are an example of the segregation of ferric oxide from metamorphic schists *in situ.* Eruptive porphyries of Leadville, Colorado, have given origin to similar segregations. The gossans of almost every mineral vein further illustrate the familiar phenomena of epigenesis of ferric oxide. The Cuban iron-ores, above described, differ from the Archean schistose deposits of Michigan and Wisconsin, and from the bedded parts of the deposits of Pilot Knob and Iron Mountain of Missouri, in the following particulars: (1) They have had their immediate source in eruptive rocks rich in protoxide bases instead of metamorphic rocks comparatively poor in proto-silicates. (2) Their ferric oxide has been concentrated without ever reaching hydrographical channels of drainage, and therefore preserved almost *in situ* without the mediation of basins. (3) The basic character of their siliceous impurities, occurring as residuums, characterizes them still further from both classes of Archean ores, especially from the schistose, whose accessory admixtures are not only acid but of the nature of segregations, intercalations and mechanical sediments. These in point of sizable development and, cursorily regarded, in general lithological appearance are, however, their nearest familiar analogue.

Besides the iron-ore bodies above described as *replacements*, another class of deposits of ferric oxide remains to be described. These may be distinguished as *concentrations.* These are partially altered diorytic masses characterized by a notable but unequal concentration of ferric oxide *in situ.* The outcropping portions of such masses are often no less rich in specular oxide than the ferric replacements of coralline, from which, however, they are readily distinguished by their superior hardness and density, and by their sharp metallic sound when struck with a hammer, as well as by the circumstances of their metasomatic association with unaltered or incompletely altered dioryte.

What has determined the localization of such deposits within the dioryte mantle has not been made clear. Certain indicated circumstances rather than well ascertained facts, seem to bear upon this question. (1) The location of such deposits, as far as recognized, is near the contact, but not uniformly immediately back of it, as in the case of the ore-bodies of coralline parentage. Some relation between the two classes of deposits may be suspected from the fact that an occurrence of this kind is recognized alongside, and probably in contact with, the developed lenticular north ore-body of West Mine Hill; while alongside a similar trappean concentration in Dry Arroyo, further up the same hill, the presence of lenticular ore-bodies of the nature of replacements is indicated.

Ferriferous parts of the dioryte referred to are usually beneath the detritus, and may be considered as representing a state of weathering intermediate between the normal dioryte and its bleached and obviously weathered products. Such occurrences are a conspicuous feature of the first range of foothills. On the Yuca Mine location, what appears to be garnetiferous casts of corallum have been found in juxtaposition with an ore-deposit of this description. This is the only relic, if such it be, of the former existence of corallines discovered by me so far back as this range of foot-hills.

The question therefore arises whether obscure and in some places obliterated corallines may not under such circumstances have given way to available replacements of which ferric oxide was but a minor part, and have determined the *loci* of such metasomatic activity or chemical permutations as to have resulted in the exchange of acids and bases in the basic and pyritiferous eruptive, followed by concentration of ferric oxide. The peroxidation of ferrous oxide *in situ* is easily conceived to have been a result from the tardy circulation, in so dense an aggregate, of chalybeate, or of solutions of the vitriolized products of iron and copper pyrites, especially under the further condition of an adjoining body of limestone. Calcic carbonate has also been at hand from decomposing silicates.

As a corroboration of the general induction, such occurrences may be held to attest an originally more basic constitution of the dioryte, and especially a once larger proportion of ferrous oxide, and accordingly of proto-silicates. Minor exhibitions of the same general class, but clearly without the mediation of limestone, are outcropping surfaces of diorytic dykes, the identity of some of which seems to have been preserved within the compass of their general overflow, or, as above distinguished, the dioryte mantle. The concentration of ferric and magnetic oxides upon such surfaces, presents outliers popularly regarded as outcrops of ore-bodies of great richness. A few blasts are generally sufficient to prove their superficial character. Cupreous stains of green carbonate from the epigenesis of a sulphide of copper, are found within the ore-bosses of coralline origin as well as in the interior of ferriferous parts of the dioryte.

The copper deposits of the Sierra de Cobre west of the Bay of Santiago, exhibit to a remarkable degree still active metasomatism of the diorytic porphyry in which they occur. Not only is the overflow of mine-water from the abandoned mines a present source of cement-copper, but exfoliations more or less cupreous are observed on all weathered surfaces of wall-rock left standing by the old English companies. Even individual fragments of dioryte detritus in the old burrows have become completely coated with exfoliated mineral matter. Ferric, as well as miscellaneous cupreous products thus occur, along with a variety of silicates and other insoluble compounds. Even the old slags show zeolitic and other drusy segregations. Secular phenomena of this kind may be considered as in part an effect of the humidity and high mean average temperature of the climate.

Under the same favorable climatic conditions secular weathering, or metasomatism of eruptive basic rocks, has gone on to a remarkable degree throughout the whole region above briefly described. Permutations of this kind tend to produce from the eruptive, now represented by dioryte, a series of rocks resembling in lithological character metamorphic chloritic, garnetiferous and ferriferous schists. The basic character of the prevailing admixtures of the latter, occurring in association with the ferric replacements of corallines, is their most obvious lithological point of difference from the prevailing type of Huronian specular schists, which as above remarked are essentially acid. Thus, they more closely resemble certain Laurentian magnetite-schists whose earthy admixtures are generally basic. Yet quarztiferous aggregates are not wanting among the great variety of ferriferous admixtures here referred to.

The ferro-garnetiferous aggregates are characterized by a subcrystalline groundmass of wine-colored garnet, probably magnesian, with druses of magnetite, and a minor proportion of the same oxide irregularly scattered throughout the mass. Narrow ledges of this rare material in West Mine Hill are remarkably continuous. Their occurrence is under such circumstances in general as to indicate their relation to the single series of dykes, the individuality of some of which has been preserved within the compass of their collective overflow. So considered, they may be taken as a special metasomatic transformation, governed by obscure local conditions, of certain dykes belonging to the same series as chloritic, epidotic and ferriferous outcrops, as well as distinct diorytic courses, readily differentiated as dykes, within the more porphyritic mantle. The latter, it is conceived, represent, under limited dynamical conditions (whence their extreme density of grain amounting in places to almost aphanitic aggregation), the least advanced state of weathering of the original eruptive. Among the numerous pseudomorphic relations of garnets, may be recognized some corresponding in kind to the metasomatic relations which may be supposed to exist between massive garnet rock and basic eruptives, along with the altered alumino-magnesian silicates whose transformation has also been wholly or in part by loss of certain ingredients.

Labradorite-dioryte more or less chloritic and of metamorphic origin, as well as metamorphic representatives of a long series of intrusive species of rocks, have been described by Prof. Dana and the late Mr. Hawes. "The fact," as remarked by Mr. Hawes, "that metamorphic action can produce rocks exactly like the igneous in external aspect and chemical constituents is of great interest in the study of rocks."* It seems almost certain that ancient eruptives afford few if any standards for such comparison where permutations of the nature of metasomatism have not led to their resemblance to related metamorphics. This may be assumed especially in the case of chloritic and epidotic rocks.

The chloritic products from alteration of the Sierra Maestra epidotic dioryte closely resemble, as above remarked, metamorphic occurrences of chloritic schists. Such resemblances tend to indicate, indeed, a middle ground where meet products lithologically identical, proceeding on the one hand from basic eruptive rocks by metasomatism, and on the other hand from sedimentary rocks by metamorphism. Resemblance between essentially chloritic aggregates of both types hardly needs the confirmation of analyses.

The dioryte of the Sierra Maestra, though not without traces of orthoclase, is essentially plagioclastic. The syenyte is mainly orthoclastic with occasional crystals of triclinic feldspars. The basalts indicated by Ansted in 1856 would now be classed as dioryte.†

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* This Journal, 1876, xi, 126.

† Proc. Geol. Soc., xii, 144.

Lehigh University, Bethlehem, Pa., Oct. 10, 1884.

ART. L.—*A New Tantalite Locality*; by CHARLES A. SCHAEFFER, Cornell University.

AMONG some specimens of the minerals found at the Etta tin mine, Dakotah, and recently come into my possession, a number of pieces, which on first glance were supposed to be cassiterite, proved to be tantalite. Professor Blake in speaking of the ore from the same locality (this Journal, III, xxvi, 235) says, "a few crystals of a black mineral believed to be wolframite have been seen in the mixtures of spodumene and feldspar." A careful search of all the specimens received has resulted in finding no wolframite but a considerable quantity of the tantalite. The probability is that tantalite is the mineral to which Professor Blake referred. An analysis of the tantalite gave the following results.

Tantalic oxide	79·01
Stannic oxide	0·39
Ferrous oxide	8·33
Manganous oxide	12·13
	99·86

This shows a much simpler composition than either the tantalite found in small quantities in Alabama and analyzed by the late J. Lawrence Smith, which contained tungstic acid and oxides of zinc and copper, or the mineral from North Carolina, analyzed by Dr. Koenig, which contained a considerable quantity of magnesia.*

The portion analyzed consisted of fragments, taken from a mass about the size of an egg, and was entirely free from any peroxidized iron. Its sp. gr. was 7·72. The determination of the sp. gr. of three small specimens, taken from a sample of stream tin, which were water-worn and externally brown, gave the following results: 6·12, 6·545 and 6·777.

Accompanying the ore, in addition to the minerals enumerated by Professor Blake, were found scorodite, containing kernels of leucopyrite, and olivenite. Qualitative examination showed the two former to be entirely free from sulphur.

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* Watt's Dict., vol. iii, 3d Supl., Pt. 2, p. 1889.

ART. LI.—*Note on Paleozoic Rocks of Central Texas;* by CHAS. D. WALCOTT, of the United States Geological Survey.

THE writer had the opportunity the past season to make a hurried reconnoissance of a portion of the Paleozoic area of Central Texas: the chief object in view being the study of the Cambrian section and the collecting of fossils from the Texas Potsdam horizon.

At all localities where the base of the Potsdam was observed, it rests, *unconformably*, on a great formation that is stratigraphically the equivalent of Powell's Grand Cañon series (Grand Cañon and Chuar groups).* In the Grand Cañon of the Colorado the latter are overlaid by the Tonto group, a series of rocks, in both lithologic and paleontologic characters, singularly like the Texas Potsdam group.

For this series of Pre-Potsdam strata the local name of Llano group is proposed from the best exposures of the group occurring in the county of Llano. Outcrops also occur in Burnet, Mason, San Saba, Blanco and Gillespie counties.

The finest exposure seen by the writer, in direct contact with the base of the Texas Potsdam group, is along the western base of Packsaddle mountain, in Llano county. Here the massive reddish colored sandstones of the Potsdam strike north and south with a slight dip to the eastward, and rest on alternating beds of shale, sandy shales, sandstone, limestone and schists that strike east and west, dipping south 15° to 40°. The strata exhibit but little evidence of metamorphism, being indurated but little more than the beds of the overlying Potsdam and Carboniferous. The section shows the Llano and Potsdam groups unaffected by changes subsequent to the consolidation of the Potsdam sediments.

Across the valley of Honey creek, four miles west of Packsaddle mountain, the strata of the Llano group have been more metamorphosed, plicated, and broken by intrusive dykes of granite. This is along the eastern base of a ridge of Potsdam Silurian and Carboniferous rocks that strike eastward with a dip that increases from 10° at the north end of the ridge to 40° at the south end. The movement producing this position, as compared with the Potsdam beds of Packsaddle mountain, appears to have been at the close of the Paleozoic, and to have caused, in part, the metamorphism of the strata of the Llano group, but was not accompanied by the intrusive rocks, as they are Pre-Potsdam—in part cotemporary with the deposition of the sediments of the Llano group, but more largely the result of extrusions of granite at or near the close of the erosion of the Llano group and before the deposition of the Potsdam. It is to this age that the great masses of granite observed in western Burnet and all through Llano county belong. At the crossing of the Llano river, on the road from Burnet to Honey Creek Cove, fragments of the shales and sandstones of the Llano group may be seen imbedded in the granite, and on Morgan's creek, Burnet Co., the Potsdam rests directly on the granite.*

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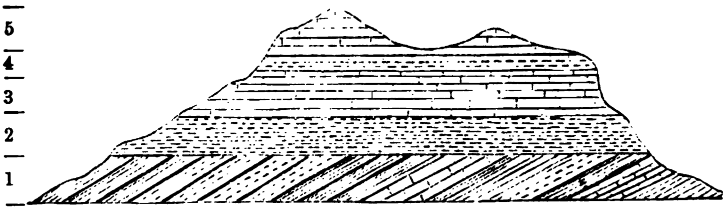
* This Journal, vol. xxvi, p. 437, 1883.

The thickness of the Llano group was not determined owing to lack of time to study it in detail. In Honey Creek valley, from two to three thousand feet of shales, sandstone and limestones were observed, and northwest of the town of Llano a great mass of reddish sandstone occurs.

On Roessler's map of Llano county,† all of the Llano group is referred to as "granitic, metamorphic and igneous," and has been considered as Archean. The writer did not observe any rocks of undoubted Archean age. No fossils were found in the Llano group, but, from its lithologic character and position in relation to the overlying Potsdam, I refer the group to the Paleozoic, and correlate it with the Grand Cañon groups which are of Paleozoic age and referred to the Lower Cambrian.‡



SECTION OF PACKSADDLE MOUNTAIN SHOWING THE UNCOMFORMITY BETWEEN THE POTSDAM AND LLANO GROUPS.

1 = Llano group.
2 = Massive Potsdam sandstone .... 205 feet.
3 = Potsdam limestone.................................. 310·
4 = Potsdam sandstone.................................. 30·
5 = Potsdam sandstone.................................. 60·
605·

POTSDAM.

The Potsdam horizon has been well described by Shumard.§ The writer collected several thousand specimens of fossils from its sandstones and limestones in order to study the fauna more thoroughly and to illustrate Dr. Shumard's species. A section was also found on the west side of Honey Creek valley that shows the contact with the Llano group below, the passage into the Silurian above, and the thickness of the Silurian up to the base of the Carboniferous.

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* It may be that further and more complete observations will prove all the granite to have been intrusive in the Llano Group prior to its erosion, but from the evidence, as seen by the writer, it is difficult to explain its occurrence except as above.

† Map of Llano county, Texas, A. R. Roessler, New York, 1875.

‡ Since the paper on the Pre-Carboniferous strata of the Grand Cañon was published (this Journal, vol. xxvi, p. 437), a fragment of a trilobite, probably of the genus Ptychoparia, has been detected in a bit of shale from the Chuar group.

§ This Journal, II, vol. xxxii, p. 213, 1861.

The section gives 245 feet of sandstone and 625 feet of limestone; all marked by the presence of an abundant Upper Cambrian (Potsdam) fauna; Lingulepis, Orthis, Agnostus, Ptychoparia and Dicellocephalus.

The upper beds of the Potsdam become compact, hard and have a little included cherty matter. The fauna terminates here as far as observed and it is not until over one thousand feet of limestone are passed through, that recognized fossils again occur. The fauna is then of the type of that of the Calciferous group. A number of fine specimens were collected of the genera Ophileta, Straparollus, Murchisonia, Orthoceras and Bathyurus.

A massive bed of limestone, sixty feet thick, rests on the Silurian beds, 1145 feet above the upper beds, carrying Potsdam fossils, and directly above it limestones of a slightly different character carry common Carboniferous fossils, viz: *Productus semireticulatus*, *P. Nebrascensis*, *P. Prattenianus*, *Streptorhynchus crenistria* and *Bellerophon* sp.?

A vertical fault, parallel with the strike of the strata, breaks the continuity of the section about 300 feet above the summit of the Silurian, and the study of the Carboniferous was not taken up in detail.

On the Colorado river, in San Saba county, a collection of cephalopod shells, of the genera Goniatites, Nautilus and Orthoceras, was obtained from the Carboniferous, and on the San Saba river a quantity of corals were collected.

The results obtained are: additional data on the Potsdam section and fauna; the Silurian section and fauna; Carboniferous fauna; the geologic relations of what has long been known as an Archean area and which is now referred to the Cambrian, and the determination of the age of the granite of Burnet county

ART. LII.—*On the Sufficiency of Terrestrial Rotation for the Deflection of Streams;* by A. C. BAINES.

IN a paper on this subject in the June number of this Journal Mr. G. K. Gilbert has investigated the combined effect of the earth's rotation and the centrifugal force in causing a difference in the velocity at the right and the left banks of rivers, and has shown that where a river flows in a curve the line of maximum velocity is shifted toward the right bank by the combined action of the deflecting force due to the earth's rotation and the centrifugal force developed in moving along a curve. Mr. Gilbert comes to the conclusion that the earth's rotation is effective in causing the erosion of the right bank, only in connection with and as an adjunct to the centrifugal force—or that the earth's rotation has no effect in shifting the courses of straight streams.

No other conclusion seems possible when only the extremely small difference in the velocity at the right and left banks due to the earth's rotation is taken into account for the small excess of erosive power at the right bank would, as has been remarked by others, be entirely neutralized if the right were only a very little higher than the left bank.

I shall examine the effect of the difference of the surface and bottom velocities of streams, in connection with the earth's rotation, and shall try to show that this difference accounts for the erosion of the right bank and deposition at the left in straight channels. In what follows, the northern hemisphere is always referred to.

If the whole water at any cross-section of a stream moved with the same velocity, every particle would be acted on by gravitation, and by the deflecting force. These forces would be equal for every particle and their resultant would be inclined to the vertical at an angle whose tangent is the deflecting force divided by the force of gravitation, and a line drawn on the surface of the stream from right to left would be inclined to the horizontal at an equal angle, and no motion of the particles of water among themselves would be caused by the earth's rotation.

The case is different in actual streams, where the velocity at the surface is greater than at the bottom. In order to simplify the investigation when this difference is considered, suppose the channel to be straight, of uniform cross-section, and the bottom flat. Also let the retarding effect of friction at the sides be omitted, taking into account only that caused by friction at the bottom.

Let v be the velocity of any particle in the stream; let v_1 be the velocity of any particle at the surface; let v_2 be the velocity of any particle at the bottom; let F be the deflecting force due to the earth's rotation on a particle whose velocity is v. Then $F=2nv \sin \lambda$ where n is the angular velocity of the earth, and λ the latitude. Let F_1 be the deflecting force on a particle at the surface; let F_2 be the deflecting force on a particle at the bottom; θ the angle of inclination to the horizon of a line drawn on the surface across the stream; w the weight of an unit of volume of water.

As in the stream now under consideration the surface velocity is greatest, θ will evidently be less than if the whole stream moved together with the velocity v_1, i. e., less than $\tan^{-1} \frac{F_1}{g}$. Also, θ will be greater than $\tan^{-1} \frac{F_2}{g}$.

It seems probable that θ will not differ much from the angle whose tan = the sum of the deflecting forces acting on a thin slice between two cross-sections near together divided by the weight of the slice.

It is not necessary that θ should be accurately determined, as the following reasoning requires only that its tangent should be between the two values above mentioned. Suppose, therefore, $\theta=\tan^{-1}\frac{2nv_0 \sin\lambda}{g}$, v_0 being some velocity between v_1 and v_2, probably not differing much from the mean velocity of the stream.

Suppose a cube of water in any part of the stream whose sides are x, y, z; x being measured along the stream, y across it, both horizontally, and z vertically. The surface of the water stands higher above the right face of the cube than above the left, by the length $\tan \theta y$. Therefore the hydrostatic pressure is greater on the right face by the quantity $w \tan \theta xyz$, or $\tan \theta W$, W being the weight of the cube. Expressing $\tan \theta$ in terms of the deflecting force and gravitation, the excess of hydrostatic pressure on the right face $= \frac{2nv_0 \sin \lambda W}{g}$. This pressure tends to move the cube from right to left across the stream in opposition to the deflecting force, and the resultant of the two forces is their difference, or $\frac{2n \sin \lambda W}{g} (v_0 - v)$, v being the velocity of the cube down the stream.

If v_0 is greater than v, as is the case if the cube is at the bottom, the resultant force is from right to left, and the water near the bottom will be urged across the stream in that direction. If v_0 is less than v, as is the case near the surface, the water must be urged from left to right.

In actual streams where the friction at the sides diminishes the velocity and the angle θ varies at every point along a line drawn across the stream. Suppose the water to be divided into a number of small vertical columns, then the above reasoning applies to each column and the forces acting on each will be similar in direction though differing in intensity, and there will be a transverse motion of the water, the surface and bottom layers moving in opposite directions, and necessarily a downward motion at the right bank, and an upward motion at the left. The resultant transverse force is greatest at the bottom and surface, and diminishes to nothing at the layer whose velocity is v_0.

The transverse motion must be extremely slow, and will be combined with that down the stream, so that the actual motion will be inclined at a very small angle to the direction of the channel. It is clear that a very slow motion of the bottom layer from right to left must cause transfer to the left side of the river bed of sand, gravel and mud, moved along by the current. The effect of this is to make the left shore more shelving, and the right steeper, and to place the deepest part of the stream near the right bank, thereby increasing the velocity, and consequently the erosion. The left shore being more shelving, will be more favorable to the resting of sediment during floods. The deposition at the left bank explains how it is that a stream can cut away a high terrace on one side, the low-lying shore on the other being added to instead of being removed.

The expression for the resultant transverse force on a particle at the bottom, $\frac{2n \sin \lambda W (v_0 - v)}{g}$, v being the velocity at the bottom, may be used to give a rough approximation to the force urging the bottom layer towards the left bank. Suppose $(v_0 - v)$ = two feet per second, the latitude 45°. The expression becomes

$$\frac{W \times 2 \times 0{\cdot}0000729 \times 0{\cdot}707 \times 2}{32{\cdot}2} = \frac{W}{156230} \text{ nearly,}$$

which is equivalent to a fall of a little less than half an inch in a mile, enough to cause a perceptible movement *down* a river channel of moderate size, and perhaps enough to cause a transverse motion above described, which would be perceptible by its effect, accumulating as it does for ages, in the same direction.

In bends, as James Thomson has shown, there is a flow of the surface water toward the convex side of the stream, and an underflow in the opposite direction. It is clear, therefore, that the deflecting and centrifugal forces must be added or subtracted, as the convex side is on the right or left side of the stream.

Christchurch, New Zealand.

ART. LIII.—*Chemical Affinity;*[*] by JOHN W. LANGLEY, Ann Arbor, Michigan.

[Concluded from page 373.]

III. THE EXISTING PROBLEM.

The history of the various modifications and additions which have been made to the primitive conception of the nature of affinity, when briefly summarized, appears to be this.

Hippocrates held that union is caused by a kinship, either secret or apparent, between different substances. Boerhaave believed affinity to be a *force* which unites unlike substances. Bergman and Geoffréy taught that union is caused by a selective attraction, and therefore they called it "elective affinity." Wenzel and his successors showed that affinity is definite in action and amount. It has limits, or proceeds *per saltum.* Berthollet contended that affinity is not definite; he proves that it is often controlled by the nature and the masses of the reacting bodies. Dalton, Berzelius, Wollaston and others, held on the contrary this force to be definite and to act *per saltum.* It is a power which emanates from the atom. Davy, Ampère and Berzelius believed affinity to be a consequence of electrical action. Avogadro, in one way, and Brodie in another, show us affinity exerted by molecules as well as atoms; it is a force which binds together not only particles of the same substance but also of heterogeneous substances.

From the fact of the actual existence of radicals and from the phenomena of substitution was developed the notion of position, and that therefore affinity varied with the structure of the body as well as with its composition. The difference between the number of atoms which are equal to hydrogen in replacing power has led to the doctrine of valence, which, if it has any influence on theories of affinity, shows that this property of matter has two distinct concepts; one its power of attracting a *number* of atoms, the other its power of doing work or evolving energy. These two attributes seem to be in no way related to each other.

Mendelejeff and Lothar Meyer have shown by the facts which are grouped under the title "periodic law" that the properties of elements seem to be repeating functions of the atomic weight. Hence affinity is connected in some way with that same property which is also shown by the differential action of gravitation on the absolute chemical unit of matter. Finally, Williamson, Kekulé and Michaelis have suggested that combination is brought about and maintained by incessant atomic interchange; hence that affinity is fundamentally due to some form of vibration.

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[*] Address before Section "C" of the American Association for the Advancement of Science, Philadelphia, 1884.

We see that the primitive notions of affinity have undergone extensive modifications. The idea which seemed so simple and natural a one to Hippocrates has grown successively more complex and less sharply defined; for while it presented itself to him as a single cause depending on kinship or occult resemblance we now find it branching out into a many stemmed structure inextricably entangled with other physical forces and having its roots deep down in the regions of the mysterious and the unknown. When we look for an advance in precision of ideas, for a logical development of a satisfactory theory, or for generalizations which shall help us better to classify chemical phenomena in terms of force and energy, we are compelled to admit that the years have not brought the theory of affinity to a state of active growth; rather it is like that strange counterpart of a living tree, the branching coral, whose many busy workers do indeed each for themselves add their mites to the accretions of past generations, but who have failed with all their toil to infuse that mysterious principle which would make of their labors a living organism ruled by an internal law of growth.

Affinity, under its own name, is no longer presented in recent manuals. Chemists have more and more turned their attention to details, to accumulating methods of analysis and synthesis, to questions of the constitution of salts, to discussions about graphic and structural formulæ, and to hypotheses about the number and arrangement of atoms in a molecule; but they have not, until quite recently, made systematic attempts to measure the energies involved in reactions. Why?

I believe the answer can be found mainly in two reasons. First, the word affinity is in bad odor; it dates back to the time when men mistook wild guesses for ascertained facts; when they knew not the distinction between physics and metaphysics, and when a plausible but flexible *occult* cause was a more welcome guest to a philosopher's brain than a stiff hard-headed fact. We see how enormously complicated the phenomena of chemical action have become and we have lost all faith in hypotheses which can be evolved by the mere force of metaphysical introspection. Therefore we are afraid to retain a name which once belonged to an idea now long buried in the limbo where so much scholastic rubbish has been consigned, and hence all the facts belonging to affinity are given under separate heads and thus they lose the great advantage of being bound together under one title.

Secondly, there is a more important reason arising from what has hitherto been the traditional scope of our science.

Natural Philosophy early sought the aid of Mathematics, and so laid the foundation for the comprehensive physics of to-day. Astronomy has always dealt with numbers, and hence stands as the best type of an exact science. Mechanics, in its analytical form, is little else than a material embodiment of algebra and geometry. Chemistry alone of the physical sciences has offered no foothold to mathematics, and yet all her transformations are governed by the numbers which we call atomic weights What is it which causes chemistry, so preëminently the analytic science of material things, to be the only one of her group which does not invite the aid of mathematics, the great analytic science of immaterial things? It is because three fundamental conceptions underlie physics while only two serve the needs of the chemist.

If I may borrow a term so much used just now by geometers, I would say that physics is a science of three dimensions, while chemistry is a science of two dimensions. In the first, nearly every transformation is followed by its equation of energy and this involves the concepts space, mass, time; while in the second, an ordinary chemical equation gives us the changes of matter in terms of space and mass only, that is to say, in units of atomic weights and atomic volume. Think for a moment what physics would be to-day without those grand generalizations, Newton's theory of gravitation, Young's undulatory theory of light, the dynamic theory of heat, the kinetic theory of gases, the conservation of energy, and Ohm's law in electricity. Every one of these, except the last, is a dynamic hypothesis and involves velocity, that is time, as one of its essential parts. In comparison with the above, all ordinary chemical work may be termed the registration of successive static states of matter. The analyst pulls to pieces, the synthetic chemist builds up; each records his work as so many atoms transferred from one condition to another, and he is satisfied to exhibit the body produced quietly resting in the bottom of a beaker, motionless, *static*. The electrolytic cell tells us the stress of chemism for specified conditions as electromotive force; the splendid work done in thermo-chemistry enables us to know the whole energy involved when A unites with B or when A B goes through any transformation however intricate, but it does not inform us of the dynamical equation which accompanies them, and which should account for the interval between the static states.

Whenever we look outside of chemistry we find the lines of the great theories along which progress is making are those of dynamic hypothesis; if we go to our biological brethren we see them too moving with the current; the geologist studies upheavals, denudation, rate of subsidence, glacial action and all kinds of changes in reference to their velocity; the physiologist is actively registering the time element in vital phenomena through the rate of nervous transmission, the rate of muscular contraction, the duration of optical and auditory impressions et cetera; and we cannot ignore the fact that all the great living theories of the present, contain the time element as an essential part. Now may it not be that the reason why chemistry has evolved no great dynamical theory, that the word affinity has disappeared from our books, and that we go on accumulating facts in all directions but one, and fail to draw any large generalization which shall include them all, is just because we have made so little use of the fundamental concept, time. To expect to draw a theory of chemical phenomena from the study of electrical decompositions and of thermo-chemical data, or from even millions of the customary static chemical equations would be like hoping to learn the nature of gravitation by laboriously weighing every moving object on the earth's surface and recording the foot-pounds of energy given out when it fell. The simplest quantitative measure of gravity, is, as every one knows, to determine it as the acceleration of a velocity; when we know the value of g we are forever relieved in the problem of falling bodies from the necessity of weighing heterogeneous objects at the earth's surface, for they will all experience the same acceleration; may there not be something like this grand simplification to be discovered for chemical changes also?

The study of the speed of reactions has but just begun; it is a line of work surrounded with unusual difficulties, but I confidently believe it contains a rich store of promise; all other means for measuring the energies of chemism seem to have been tried except this; is it not therefore an encouraging fact that to us, the chemists of the nineteenth century, is left for exploration the great fruitful field of the true dynamics of the atom, the discovery of a time rate for the attractions due to affinity.

ART. LIV.—*Peculiar Modes of Occurrence of Gold in Brazil*; by ORVILLE A. DERBY.

1. NATURAL DEPOSITION OF GOLD FROM SOLUTION.

THE following facts are believed to justify the heading of this paragraph. A specimen (Mus. No. 84) in the National Museum at Rio de Janeiro shows films of gold which are difficult to account for on any other hypothesis. The specimen was received some thirty years ago from the Danish Collector Claussen, with the indication "gold on limonite, Ponte Grande, Sabará, province of Minas Geraes." The formation at this place consists of hydromica schists with granular quartzites (itacolumite) and itabirite. The region abounds in old alluvial washings and rock mines in quartz, itabirite and pyrite, those in the latter material being the most important. The geological formation at the Sabará bridge is identical with that of the country rock of the great pyrite vein at the celebrated mine of Morro Velho some fifteen miles away.

The specimen in question is about six centimeters square and two centimeters thick, and consists of white vein quartz. A bit of adhering country rock on one margin shows this to have been a very quartzose micaceous schist. Judging from the appearance, the fragment came from one of the ill-defined and irregular lines of quartz which traverse the rocks of this region generally coincident with the bedding. The lower side, which is almost perfectly flat and seems to have rested on a bed of the country rock, is coated with a thin crust of rusty brown limonite and presents nothing of interest. The other side though flattened is more irregular and had evidently formed one of the walls of a narrow open fissure which had become lined with a crust of black botryoidal limonite less than a millimeter in thickness. The greater portion of the polished surface of this crust is covered with an excessively thin varnish-like film of an iridescent bronzy color. Similar crusts, some of them presenting the bronzy film, line the numerous small cavities of the quartz which appear to have been left by the decomposition of pyrites. Still a third crust or film of reddish brown earthy limonite forms a V-shaped streak about five millimeters broad, at one side of the specimen. This film, though very thin, is of appreciable thickness and rests on the polished surface of the black limonite, from which it may be detached in minute flakes by a very slight pressure with a metal point. On various parts of the specimen, but particularly along the whole length of the V-shaped streak, are minute detached films of gold, the largest of which cover a surface equal to about a square millimeter. These gold films adapt themselves perfectly to all the irregularities of the botryoidal surface of the limonite, and under the microscope are seen to be uniform (not composed of distinct grains joined together) and to present a surface like frosted metal work. The character of the surface is precisely like that of the limonite crust of the V-shaped streak, which, unlike that of the black limonite and of the iridescent film, is not polished. Similar films (as regards adaptation to the irregularities of the limonite and character of surface) were obtained by allowing a drop of mercurial ointment to dry on the surface of the specimen.

We have here, therefore, gold resting on the surface of a secondary mineral (limonite), and in such conditions that it may be compared to films of limonite deposited from an aqueous solution, or of mercury deposited from suspension in fatty matter. It seems impossible to regard these gold films as transported granules simply lodged against the surface. Their perfect adaptation to the surface on which they rest, their almost inappreciable thickness and their uniformity of structure and of surface, whether large or small, are against this view. In order to judge of the probability of this hypothesis I made the following experiment to determine the state in which fine gold occurs in the rocks of the region. A fragment of arsenopyrite assaying about five ounces to the ton, coming from about 500 meters below the surface in the Morro Velho mine, was dissolved in acid. The exceedingly minute specks of gold obtained in the residue are distinctly granular and crystalline. The smallest, an octahedral crystal, measures 0·075 millimeters, while the largest, an irregular group of crystals, is 0·375 millimeters long. The fine gold of São Gonçalo described in the following article, is of the same character. Such grains could not possibly be lodged against the surface so as to produce films of the appearance of those here described.

The V-shaped streak of earthy limonite shows some peculiarities that seem to throw light on the process of introduction of the gold. Its outer margin is distinctly thickened, showing that the iron-bearing solution stood for some time upon it with a tendency to flow onward, causing a piling up of the liquid at the margin and a consequent thickening of the matter deposited from it. As before remarked, the gold is more abundant on this streak than elsewhere on the specimen, and more abundant on the outer than on the inner half of it, as would naturally occur if it had been deposited from a solution which had been for some reason, dammed back, so as to remain for some time on the place of the streak while it slowly evaporated, as the iron deposit proves to have actually occurred. On removing a little of the iron crust similar films of gold are seen resting on the botryoidal surface underneath the streak. These had evidently been formed before the accumulation of liquid from which the streak was deposited. Some of the gold films outside of the limits of the streak were also most probably deposited at the same time and in the same manner. Of these the greater number occur in a considerable patch, slightly discolored with iron, just below the angle of the V, as if the liquid which deposited gold on the streak had flowed over at this point, that of greatest accumulation, on the adjoining surface, carrying a little iron with it.

The facts above noted appear to be susceptible of the following interpretation as regards the course of events in the history of this specimen. In a narrow open slit of a quartz vein containing pyrites, a crust of botryoidal limonite was deposited lining the walls of the cavity. After its formation this crust became moistened with an iron and gold-bearing solution which deposited the extremely thin film of iridescent limonite (?) and scattered films of gold. Afterward a more abundant supply of liquid gathered and rested for some time, or until it evaporated, in a long, narrow V-shaped band, being prevented from flowing on and spreading evenly over the whole surface by projections of the opposite walls of the slit, or more probably by adhesion to the surface of the limonite; as the liquid slowly evaporated it deposited first its iron, thickest at the margin where adhesion would cause a piling up of the liquid, and afterward its gold, which, instead of spreading evenly over the surface, gathered in certain points by a concretionary action. During the deposition of the iron the upper portion of the liquid, becoming lighter than the lower, flowed over at the lowest point where the accumulation was greatest and, carrying with it gold and a relatively small proportion of iron, produced the thinner film of iron with gold below the angle of the V.

2. GOLD IN GNEISS.

Gold, almost universally worked from veins or from debris derived from them, is supposed to have come in some way from the adjoining rocks (Dana's Mineralogy, 5th ed., p. 6), but thus far no case of its occurrence in workable quantities throughout the mass of such rocks seems to have been recorded. Museum specimens of country rock charged with gold are comparatively common but in such cases the deposition of the precious metal in the rock is clearly connected with the filling of the adjacent vein. The gold-bearing itabirites of Brazil come nearer to a case of the distribution of gold throughout a rock independent of well-defined veins, but even here the irregular pockets of friable iron ore (*jacutinga*) and lithomarge, in which the gold is found so abundantly, partake somewhat of the nature of veins. The district of Campanha and São Gonçalo in southern Minas Geraes, however, afford an example of extensive mining operations in decomposed gneiss in which the almost complete absence of veins and of the other usual concomitants of gold is remarkable.

This district lies some fifty or sixty miles to the southwest of São João D'el Rei which may be taken as about the southern limit of the rich belt of auriferous slates, quartzites and itabirites which constitutes the best known and most famous mining region of Brazil. In approaching the region from the sea coast one crosses the high gneiss ridge of the Serra da Mantiqueira and then traverses for a distance of fifty miles or more a high mountainous plateau composed, for the most part, of rounded hills and knobs of profoundly decomposed gneiss. Above these rise several hills and ridges of compact gneiss and at least one ridge of granular quartzite, the Serra de São Thomé das Lettras, mentioned in the preceding article on itacolumite. The quartzite, however, constitutes only a subordinate feature in this region which may be described as almost wholly gneissic; and the accompanying auriferous schists, which characterize the typical gold-mining region of Minas, have not been noticed in this part of the province, though it is probable that they occur. The limits of this mining district have not been traced. Old workings may be seen over a very considerable area all the way from the Rio Verde to the Sapucahy, a distance of twenty-five to thirty miles. The most important centers of the mining operations were, however, the city of Campanha and the village of São Gonçalo, at and between which the following observations were made. Mining has been carried on in this district to a greater or less extent down to the present day, but the most extensive operations seem to have been at about the beginning of the present century. Spix and von Martius, who passed through Campanha in 1818, speak of it as, at that time, a prosperous mining town, the mines having been opened a few years before, while São Gonçalo was already on the decline.

The road from Campanha to São Gonçalo, twelve to fifteen miles long, passes through a region of rounded gneiss hills, so profoundly decomposed that rock is only seen in the beds of the streams and, in a few cases, in the bottom of the old mines. To the eastward there is a high rocky gneiss ridge, known as the Serra das Aguas Virtuosas, from mineral springs at its base, which rises some two or three hundred meters above the general level. To the westward a similar parallel ridge, called the Serra de São José, extends from São Gonçalo about half way to Campanha. These two ridges have a northeast-southwest trend corresponding with the general strike of the rocks of the region. Among the foot-hills of the latter ridge and along a line extending from its extremity to Campanha there is an almost continuous string of old washings often covering several acres and cutting deeply into the hillsides, as extensive as can be found any where in Minas. The feature that particularly strikes the observer accustomed to the deep and narrow open workings, suggestive of railroad cuttings, of central and northern Minas where decomposed vein stuff or thin intercalated beds have been followed, is the great superficial area and nearly uniform depth of the greater part of these old washings. They are suggestive of placers, but on entering them one is surprised not to find gravel heaps and only a comparatively thin mantle of transported clays at the top, the greater part of the walls and all the bottom being of decomposed gneiss which is evidently *in situ*. The comparative rarity and insignificance of the quartz veins is equally surprising, and when they occur there is no evidence of their having been followed in preference to the enclosing rocks which have been worked away in mass. Indeed the veins are said to be generally barren, though that this is not always the case is proven by one of the mines at São Gonçalo where a little work has been recently carried on along a face twenty feet or more in width traversed by a small vein which affords a richer streak. Some of the hills, as that of the Cata Funda at São Gonçalo, have been worked in ledges or terraces, successive coats of a thickness of a few meters having been more or less completely stripped off as one would peel an onion. In this manner nearly the whole of one side of an elongated ridge a quarter of a mile or more in length had been stripped from base to summit over a width of a few hundred meters. This mode of working is of itself sufficient to prove that the gold was found in workable quantities very generally distributed throughout the mass of decomposed gneiss. This same conclusion is presented in an unpublished report to the Brazilian government by the late Prof. Hartt, who visited São Gonçalo in 1875. Tests made on the clays resulting from decomposition at numerous points selected at random, and on masses of half decomposed gneiss still retaining their form which had been thrown out of a pit, all showed traces of gold and thus confirmed this conclusion.

At São Gonçalo and Campanha the rock is completely decomposed, and it is only by an examination of the clay banks that its original character can be determined. At Santa Luzia, however, about midway between the two places, one of the old workings has uncovered a considerable surface of solid rock in which work was being carried on at the time of my visit. This mine, called Andaime (scaffold), is situated on the top of a hill in which, for some reason, decomposition does not seem to have been so profound as in the other hills of the neighborhood. The older workings show the same characters as those above described; but at present only richer streaks are being followed in the exposed gneiss which, though still retaining its form and stratification, has been sufficiently softened by decomposition to admit of its being easily reduced to a paste with water by the use of crowbars and hoes. The rock is a blackish highly micaceous schistose gneiss, with many thin seams of quartzites, which in places increase to beds of about a meter in thickness. The strata are much contorted, but the general strike seems to be about due east, with a dip of 30° to the south. A small vein of pegmatite traverses the beds. Mining is at present confined to one of the thicker beds of quartzite which is considered the richest, but very good tests were obtained from the black gneiss and also from loose masses of reddish half-decomposed rock much more feldspathic than that in contact with the quartzite bed. Considerable iron sand was obtained in all these tests.

The washings at São Gonçalo lie on both sides of a small stream that flows near the base of the Sérra de São José and parallel with it. On the town side a broad belt over a mile long has been almost continuously washed, and it is said that other washings make with these an almost uninterrupted belt of washed ground as far as the mouth of the stream in the Sapucahy, a distance of about three miles. The washings on the other side of the stream are less extensive, but there is the same tendency to a linear arrangement parallel to the stream and to the Serra, and in the direction of the strike of the rocks. It thus appears that a heavy bed or set of beds is auriferous throughout a thickness of some hundreds of meters and for a distance of several miles along the strike. Although the decomposed material has been very generally washed, traditions speak of richer streaks, and there is some reason for supposing, from the few experiments made, that the more quartzose and ferriferous portions are richer than the generality of the mass. The proportion of gold shown by a single panfull of dirt is very small and the average richness must be very low. I was informed that some recent tests on a measured quantity of dirt gave about fifteen cents of gold per cubic meter.

Owing to the extensive decomposition, there is considerable difficulty in obtaining unaltered specimens of the rock in contact with the auriferous dirt. The only good exposure seen was in the bed of a small stream just below São Gonçalo and near one of the old mines. A panfull of dirt taken a couple of feet above the undecomposed rock gave a color of gold, so that the specimens obtained may fairly be assumed to be auriferous. The rock is here a massive, fine-grained, black and white gneiss, approaching granite in aspect but with a slight tendency to a stratified arrangement in the flakes of mica. The mica is abundant in fair-sized black flakes; the quartz is in small well-formed crystals and is the least conspicuous ingredient, while the feldspar, which is the most abundant of all, is white, a large proportion of it being plagioclase. In the microscopic sections examined, no magnetite or pyrite was detected, but magnetic sand was always found in the tests made of the soft material, and one or two very small crystals of pyrite were found on examining a hand specimen. In view of the almost constant association of pyrite with the gold of the central and northern parts of the province in the auriferous schists, quartzites and itabirite series, its rarity here is very noticeable. The quartz sand obtained by washing the decomposed gneiss, as well as that from the quartzite bed at Santa Luzia, was in well formed doubly terminated crystals.

The gold of this region is excessively fine. A number of specimens from São Gonçalo and Santa Luzia examined microscopically showed distinct crystalline grains, with sharp, well defined angles. Nothing of a leafy character or resembling the flakes on limonite described in the preceding article were noticed. The grains range in size from 0·05 millimeters for single crystals up to 0·4 millimeters for agglomerations of several crystals, and present the same characters as those obtained by dissolving the arsenopyrite of the Morro Velho vein.

As a company has been recently organized to reopen the São Gonçalo mines by the hydraulic method it is to be hoped that further details regarding this interesting region may soon be obtainable. As already mentioned, a few small gold-bearing quartz veins occur, and in future examinations under more favorable circumstances it may be possible to determine something bearing on the question as to whether or not these veins have been enriched from the adjacent rock.

Art. LV.—*On Colemanite, a new Borate of Lime;* by A. Wendell Jackson.

A new borate of lime has recently been determined by J. T. Evans, of the California Academy of Sciences. His analysis fixes its formula as follows:

$$2CaO \,.\, 3B_2O_3 \,.\, 5aq.$$

It differs from pandermite in containing five instead of three molecules of water. Its main interest lies however in its morphological relations. Mr. Evans kindly sent me a crystal for investigation and subsequently I obtained from another source twenty other crystals. They are all small, colorless and in the main with faces in good condition. The examination in the polariscope showed that the crystals were monoclinic. The plane of the optical axes is normal to the clinopinacoid and makes an angle of 83° 25′ with the chief axis (in front).

With a primitive form having

$$\grave{a}:\bar{b}:\overset{\shortmid}{c}=0{\cdot}774843:1:0{\cdot}540998 \text{ and } \beta=69^\circ\ 50'\ 45''$$

I have determined already the following forms:

Pinacoids: $\infty P\bar{\infty}$, $\infty P\grave{\infty}$, $0P$.

Prisms: $\infty P\grave{3}$, $\infty P\grave{\frac{4}{3}}$, $\infty P\grave{2}$, $\infty P\grave{\frac{18}{10}}$, ∞P, $\infty P\bar{2}$.

Clinodomes: $P\grave{\infty}$, $2P\grave{\infty}$.

Hemidomes: $\frac{68}{11}P\bar{\infty}$, $6P\bar{\infty}$, $4P\bar{\infty}$, $2P\bar{\infty}$, $P\bar{\infty}$, $-P\bar{\infty}$.

Hemipyramids: P, $2P$, $-P$, $-3P$, $-\frac{12}{6}P$, $2P\bar{2}$, $3P\grave{\frac{3}{2}}$, $4P\grave{2}$, $\frac{3}{2}P\grave{\frac{3}{2}}$, $2P\grave{2}$, $3P\grave{3}$, $-3P\grave{3}$, $3P\bar{3}$, $4P\bar{4}$, $-3P\bar{3}$.

The crystals are all highly complex; one of them has twenty-four different forms upon it. At least two distinct types are represented; one in which the basal pinacoid and the hemidome $P\infty$ are largely developed and the other with basal pinacoid and most of the hemidomes either absent or very small. The primitive prism ∞P is largely developed upon all and determines the prevailing columnar habit of the crystals.

ART. LVI.—*On the Decay of Quartzyte, and the formation of sand, kaolin and crystallized quartz;* by JAMES D. DANA.

FACTS from the quartzyte regions of Massachusetts, Connecticut and Vermont fully sustain the observations of Mr. O. A. Derby on itacolumite, published in this volume (page 203), and appear to throw light on the nature of the change producing it.

1. *Sand from quartzyte.*—The occurrence of loose quartz sand and friable sand rock in connection with the Berkshire County quartzyte has long been known, and for many years the product (obtained mostly from crushing the friable rock) has been used for making glass. The most extensive localities and those earliest worked are in the town of Cheshire, a few miles north of Pittsfield, as mentioned in Professor Hitchcock's Geological Reports of 1832 and 1842. The sand-works are situated just west of the railroad station, also one mile and two miles south of it, and two miles to the eastward, near the borders of the town of Savoy. The oldest working is three miles south of Cheshire, and until 1832 it was the only one in Berkshire. At the quarry two miles south of Cheshire village the rock is friable to a depth into the hillside of at least 300 feet; and at this, and other such localities, I have found it unsafe to rely on the present position of the layers for evidence as to the true position, the weakened beds tending to slip out of place by gravity.

I have visited also a locality, formerly worked, in the town of Savoy, about six miles east of the village of Cheshire; and another four and one-half miles east of Dewey's station (Housatonic railroad), near the center of the town of Washington and just south of Ashley Lake. I have found the friable quartzyte also at a kaolin deposit in the quartzyte region of high northeastern Sharon, in Connecticut, and impure varieties at numerous other localities.

2. *Kaolin from quartzyte.*—At the Cheshire sand-works, south of the village, the waters that flow from the quarries, or stand in pools within them, deposit some kaolin over the bottom. The friable rock is well exposed at the quarry two miles south in a bluff front, and between its layers here and there occur thin seams of kaolin; the layers of quartzyte are two to four or five inches thick, and the underlying seam of kaolin usually a twentieth to a fiftieth of an inch; the latter appeared for the most part to have been derived from the overlying quartzyte layer. One layer of quartzyte a foot thick had the kaolin throughout it and was worthless, as the superintendent remarked, for sand-making. A specimen of the kaolin analyzed for the company by Dr. A. A. Hayes, of Boston, afforded 75 per cent of silica to 25 of alumina, equivalent to a half-and-half mixture of kaolin and quartz sand. Similar facts were observed at the works a mile south of Cheshire.

At the sand-quarry in Central Washington, south of Ashley Lake, the quartzyte—which varies in firmness from the hardest to the most friable, from no bedding to thin-bedding—sometimes has the layers alternating with seams of soft kaolinized feldspar; and occasionally this material is so mixed with the quartzyte as not to be easily recognized, except that the crumbled quartzyte is a little coherent.

Many kaolin beds of western New England occur in quartzyte areas. This is true of the largest of these deposits, that in the southwest corner of New Marlborough near the Canaan (Conn.) boundary; the kaolin is sandy and contains fragments of quartzyte; it has bedding from short transportation. It is true also of that of northeastern Sharon, where the kaolin contains much sand and its working brought to the surface the friable quartzyte; also of a small deposit just east of Monument Mountain, between Stockbridge and Great Barrington. The large kaolin deposit of Brandon, Vermont, has quartzyte to the eastward as the nearest outcropping rock, and far the larger part of the clay is white, and thus pure from iron oxide. That of Monkton, Vermont, also a large deposit, is in a sandstone region, independent, says Professor Hitchcock in the Vermont Report (1861), of any limonite bed. That of Pownal, described by Dr. C. Dewey (this Journal, xii, 298, 1827), and spoken of by Professor E. Emmons as "a large bed of porcelain clay," is also in a region of quartzyte.

3. *Feldspathic quartzyte the source of the kaolin.*—Feldspathic quartzyte occurs near the line between Lenox and Washington, in the latter town, two miles east of Dewey's railroad station and four and one-half miles south-by-east from Pittsfield.* Large blocks, evidently derived from a bed in the underlying quartzyte of the region, and cavernous from the removal of most of the feldspar, lie over the field; the narrow ragged cavities are often an inch or more long. Dr. C. Dewey, who describes the

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* The locality is south of the house of A. Dexter (situated near the junction between the road from Dewey's to Washington and another short road going north, one-half mile west of the school-house corner), in the field south of the road.

rock in this Journal for 1824 (viii, 17), says of it that "it is wrought into millstones ofter the manner of the Paris buhrstone," and goes by the name of the *Pittsfield buhrstone.* Feldspar exists in some of the cavities. Professor E. Hitchcock recognizes the feldspathic character of the rock in his Massachusetts Geological Report of 1842, saying (p. 587), that the buhrstone is "a variety of gneiss rock whose feldspar has decomposed and disappeared, and in which quartz was greatly the predominant ingredient." The name gneiss given it is not so far out of the way as might at first seem; for some of the rock contains besides the feldspar and quartz a little mica. The hearth-stone quartzyte quarried not half a mile southeast of the locality, which affords the best of hearth-stones of western New England, contains black mica in very minute scales disseminated through it, like much of the quartzyte elsewhere. Professor Hitchcock mentions another locality of it: "four or five miles south of the spot where millstones are prepared," at which the rock "may be seen in all stages of the process between gneiss and buhrstone."

Professor Hitchcock states, in the Vermont Report, that the same kind of feldspathic cavernous quartzyte is common in connection with the quartzyte formation of Vermont, and (p. 343) that bowlders of this variety near Bennington, Vt. (where the eastern mountains are chiefly of quartzyte), were formerly so numerous that "all the feldspar used in the pottery-works was obtained by crushing them and separating from the fragments the crystals of this mineral."

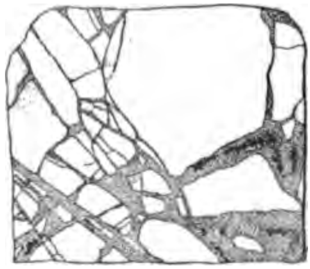
Professor E. Emmons describes the same feldspathic variety of quartzyte in his New York Report of 1842 (p. 159), speaking of it as a rock "in which feldspar exists in small crystals of white or yellowish-white color," that disappear by decomposition leaving a porous quartz resembling buhrstone, and he mentions the town of Pownal, Vermont, as affording it abundantly. He also states in the chapter in his American Geology (vol. I, Part ii), on the Taconic System, that Oak Hill (in northeastern Williamstown and the adjoining part of the town of Adams), which consists of quartzyte with some micaceous and gneissoid beds, has a layer of feldspathic buhrstone-making quartzyte near its eastern foot. At the quartzyte quarry in Sharon, Conn., southeast of the village, I found the quartzyte to graduate into a feldspathic variety which had nearly the characters of granulite; and at a quarry in northeast Sharon, just east of the kaolin locality above mentioned, the same graduation takes place; a specimen of the feldspathic quartzyte received from Mr. J. S. Adam is nearly halt feldspar. The feldspar in the quartzyte is cleavable orthoclase as far as I have observed.

At a locality of kaolin in the south part of Kent, the rock from which the kaolin originated is, as stated by Professor C. U. Shepard in his report on the Mineralogy of Connecticut (p. 74), a kind of "graphic granite which must have been free from mica," in other words, a rock consisting of quartz and feldspar; and at other, three miles west of New Miford, which the same author scribes, the rock is altered in place, the quartz and altered feldspar ving the same relative position "as in the undecomposed rock."

The natural conclusion from the above facts is (1) that the por- ain clay or kaolin has come from the feldspar of a feldspathic artzyte. The quartzyte contained much feldspar and only traces pyrite and mica, and was easily permeable to water, and hence fitness for making deposits of pure white clay—such as is t possible from the decomposition of an ordinary mica schist. ıe black mica of a mica schist contains much iron and even the ht-colored muscovite and damourite usually three to six per cent iile the quartzyte has almost none and the little oxide that is ide is readily removed by percolating waters. No beds of iite kaolin of workable value occur with the limonite deposits western New England which I have examined, although clays ound in them.

It is further evident (2) that the quartz sand and friable part of e quartzyte are produced by the removal of finely disseminated dspar; while (3) the buhrstones, as Emmons and Hitchcock mark, have resulted where the feldspar is disseminated in largish eces through the quartzyte.

4. *Pseudo-breccia from Quartzyte, and in some of this pseudo- ccia crystallized quartz.*—A very common source of the de- uction of quartzyte is the oxidation of its pyrite, as is well own—a mineral that is often present yet in general very spar- gly. One peculiar result of this oxidation is a pseudo-breccia. ecimens of it look like a coarse quartzyte breccia having a ruginous cement; and Dr. Dewey in 1824 (this Journal, viii,), and Professor Hitchcock in his Report of 1841 (p. 588), so ll it, the latter remarking that he d not succeeded in finding it in ace. It occurs in bowlders in Can- n, Conn., and in many parts of rkshire, Mass.; and in northeastern ıeshire it appeared to be in place, ıt characterized only an outer por- on of the bed. This pseudo-breccia, the above figure plainly shows, is quartzyte that has been divided up a succession of cracks and has nonite *coloring* the rock alongside of the cracks, and also depos- d in them. Many of the pieces, in the specimen figured, lie *in ace*, barely separated from one another, and appear to be under- ing new divisions. But in the lower part large pieces look as there had been wide displacements; yet the hardly disturbed ndition of the upper half proves that the apparent displacement due to the extension of the coloring and penetrating limonite. he cracks are made in part by the extremely slow wedge-like tion of the depositing limonite.



The figure represents cavities within some of its dark limonite-colored bands. This feature I have best seen in the interior of a specimen, about six inches in diameter, found in Canaan, Conn. The cavities occur in all the larger bands. They are generally elongated in the direction of the band, and sometimes are in two narrow lines in a single band, one near each side. The largest cavity is a ragged shallow one two inches long and one inch broad; and another has half these dimensions. These cavities contain a coating of limonite. The prying action attending the oxydizing process tends to loosen grains as well as open crevices; but, if the quartzyte were originally solid, the mechanical removal of the separated grains so as to make cavities in its interior would be impossible. The cavities may have been produced by the removal of largish pieces of pyrite, or of both pyrite and feldspar, but whether so or not, the facts are insufficient positively to determine. The presence of feldspar is rendered probable by the occurrence of a kaolin-like material in a few otherwise empty cavities in the body of the quartzyte.

Further: *the cavities described have generally a lining of minute crystals of quartz;* and these crystals coat the limonite, showing that the crystals were deposited after the limonite. The drusy quartz also penetrates to such an extent the limonite-colored bands, that it is probable that they were formed also during the making of the limonite, and at the ordinary temperature.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Cause of the discrepancy between the observed Electromotive force of a Battery and that calculated from thermochemical data.* — Many voltaic cells have an actual electromotive force quite different from the theoretical electromotive force calculated from thermochemical data. Some of these, those containing iron, nickel or cobalt in a solution of potassium hydrate, for example, show polarization phenomena markedly, as Becquerel pointed out in 1856. These cells, though the positive electrode is unpolarizable, give a current which rapidly falls to zero. So a cell having an electrode of aluminum in dilute sulphuric acid and one of copper in sulphate of copper solution, gives an electromotive force of only 0·62 volt instead of 2·06 volts as required by theory, and a cell having magnesium and platinum plates in potassium hydrate is, contrary to thermochemical data, less energetic than a zinc platinum couple in the same liquid; being 1·35 volts instead of 1·43. Although polarization is generally considered capable of modifying the electrical energy only when a current is produced, yet it appeared quite possible *à priori* that the cause producing this phenomenon might also affect the static electromotive force. CHAPERON has accordingly made a series of experiments upon

larization of the metals above mentioned, in solutions
the most marked anomalies. The apparatus was arranged
ecomposing cell, the electrodes being connected with a
by means of a key which allowed the plates to be
tely put in contact with this battery and with a micro-
ondenser. After several alternations the armatures of the
ser acquired nearly the same difference of potential as the
um given by the electrodes. By means of a ballistic
ometer or an electrometer, this difference of potential was
ed. When the electrodes were of distilled zinc placed in
lphate solution, and called unpolarizable, charged with an
motive force of one volt, three contacts of the key gave
denser a charge of only a few hundredths of a volt, which
increase by further repeating the contacts. But with a
able system on the contrary, after three or four contacts,
denser was found charged to a difference of potential of
or quite a volt. On plotting the results in the form of
whose abscissas represent the differences of potential of
rging source and whose ordinates are the differences given
condenser by the electrodes, it appears that for the metals
lutions studied, polarizable systems are produced under
ircumstances whose difference of potential increases con-
lly from zero up to the point of decomposition of the
lyte into its elements. Thus with electrodes of magne-
n alkalies, this electromotive force reaches 3·8 volts and
uminum in acidulated water, more than 4 volts. Repre-
by T_{RH} the energy of formation of an electrolyte com-
of the elements R and H, by T_{mR} and T_{mH} the electric
of replacement of the elements R and H by an electrode of
able metal *m*, the chemical work corresponding to the
energy returned by two polarized electrodes will be in
$T_{RH}-T_{mR}-T_{mH}$. Now since the polarization as above
follows a continuous law of variation, this chemical work
ry in value from T_{RH} to zero; i. e., between the point of
lysis and the neutral condition of the electrodes; thus
at the lower limit the equation $T_{RH}-T_{mR}-T_{mH}=0$. So
R and T_{mH} may vary from zero to two positive values, each
t the limit, smaller than T_{RH}. It is therefore this limiting
f T_{mR} in the above equation which should be used in calcu-
the theoretical electromotive force in place of the heat of
ation.—*C. R.*, xcviii, 729; *J. Chem. Soc.*, xlvi, 802, Aug.,
G. F. B.

n the Color of Chemical Compounds as a function of the
weights of their constituent Elements.—CARNELLEY has
attention to the fact that the color of chemical compounds
ls at least upon three conditions: 1st, the temperature,
quantity of the electronegative element in a binary com-
and 3d, the atomic weight of the constituent elements.
st two of these conditions were studied by Ackroyd, who
ed (1) that all chromium compounds change color in a defi-

nite direction, an increase in the temperature producing tints extending more and more toward the red end of the spectrum, becoming finally brown and black if the heat be sufficiently increased. Ordinarily the color passes from white directly to pale yellow, omitting violet, indigo, blue and green as transition stages. (2) That in binary compounds an increase in the quantity of the negative element produces a change of color toward the red end of the spectrum, ending finally in brown and black; for example, PbO is yellow, Pb_3O_4 red and PbO_2 brown. Carnelley formulates the third condition thus: In certain series of compounds A_xR_y, B_xR_y, C_xR_y, etc., in which R is an element or group of elements, while A, B, C, etc., are elements belonging to the same sub-groups in Mendelejeff's table of natural classification of the elements, the color varies either entirely or partially through the following scale of color as the atomic weight rises: White (or colorless), violet, indigo, blue, green, yellow, orange, red, brown and black; in other words, the higher the atomic weight of the elements A, B, C, etc., the more the color of the compound approaches the red end of the spectrum, becoming in many cases brown or black. Obviously the elements A, B, C, etc., must belong to the same sub-groups. Oxides cannot be compared with the corresponding sulphides, selenides or tellurides, nor fluorides with the corresponding chlorides and iodides. Out of 426 comparisons made by the author, he observed only 14 exceptions to this law. Since the vibration-period of a molecule is lower the less dense its mass, it follows that when this period is less than that corresponding to the violet, no visible vibrations are absorbed and the body is colorless; but as the molecular weight increases, the violet rays are first absorbed and the body appears of the complementary color, greenish yellow; and so on. Increase of temperature, by lessening the cohesion, also diminishes the vibration-period. The author thinks there is some evidence that the color of compounds is a periodic function of their atomic weights.—*Ber. Berl. Chem. Ges.*, xvii, 2151, Sept., 1884. G. F. B.

3. *Gas Analysis under greatly diminished Pressure.*—LOTHAR MEYER and SEUBERT have made a series of experiments on the force of gaseous explosion under diminished pressure, the results of which confirm the observation of Thomas that rarefaction produced by diminishing the pressure is more effective in weakening the force of explosion than is dilution with an indifferent gas. In consequence, the authors recommend that the explosions required in gas analysis be made under diminished pressure and they have contrived a modification of the vapor-density apparatus of Schoop to be used for this purpose, the results being rapid, accurate and safe. Experiments to ascertain the pressure at which explosive gaseous mixtures could be fired without injury to the apparatus, showed that for methane and oxygen, the best pressure was 140^{mm}; for propane 80^{mm}; for ethylene 70 to 80^{mm}; for acetylene 40 to 50^{mm}; carbon monoxide 230^{mm}; hydrogen 100 to 125^{mm}. In making an analysis the eudiometer is filled with

mercury in the usual manner and the gas to be analyzed is introduced, in amount about one-tenth of the capacity of the tube. By means of a cathetometer the level of the mercury in the eudiometer and in the barometer is read off. The pressure on the gaseous mixture is then diminished to the required extent by lowering the mercury reservoir and the spark is passed. If there is no explosion, the reservoir is raised a little and a second spark is passed; the normal pressure is then restored and another reading taken. The carbon dioxide formed is then absorbed by sodium hydrate and the volume of the gas is again read. The results are calculated as usual. In a subsequent paper by Lothar Meyer, valuable suggestions are given on the calculation of gas analyses.—*J. Chem. Soc.*, xlv, 581, Oct., 1884. G. F. B.

4. *On the Synthesis of Galenite by means of Thiocarbamide.*—**Emerson-Reynolds** has shown that the ready desulphurization of sulphur-urea or thiocarbamide by metallic oxides notably those of silver, mercury and lead, may be made use of for the purpose of obtaining their sulphides. When heated with an alkali-solution of lead hydrate, for example, the lead sulphide separates sometimes in a galenoid form yielding a firmly attached specular layer on the sides of the vessel. To prepare the lead solution, 90 grams of sodium hydrate and 75 grams lead tartrate are dissolved in a liter of water. The thiocarbamide solution contains 17 grams per liter. On mixing equal volumes of the two solutions and heating, a brownish color appears at about 38° to 40° C., the whole becomes turbid at about 45° and a specular layer forms on bottom and sides of the vessel, which increases in thickness continually, reflecting light of the same color as a brilliant face of a crystal of native galenite. After ten minutes boiling the liquid is free from any trace of lead. The deposit has the composition PbS: when thin it shows no structure under the microscope; but strong specular layers slowly deposited are seen to be distinctly granular. In the case of some deposits on rough surfaces, brilliant octahedral or tetrahedral faces were observed. The use of this process for plating articles of glass and metal with galenite has already been secured by patent.—*J. Chem. Soc.*, xlv, 162, June, 1884. G. F. B.

5. *On the Action of active and inactive Amyl chlorides and of Amylene upon Toluene in presence of Aluminum chloride.*—**Essner** and **Gossin** have shown that active amyl chloride reacts upon toluene with great facility in presence of aluminum chloride yielding a series of products, the chief of which boils between 207° and 209°, gives on analysis the ratio $C_{12}H_{18}$, has a vapor density of 5·54, and is evidently an amyl-toluene. It is a colorless liquid, having an aromatic odor slightly like camphor and has at 22° a density of 0·8679. Oxidized with permanganate, it gave a solution containing only isophthalic acid apparently: though minute quantities of ordinary phthalic and of terephthalic acids were present. The inactive amyl chloride also reacts upon toluene and yields a product boiling at 207° to 209°, which presents all

the properties of the body obtained with the active chloride. Amylene also acts upon toluene in presence of aluminum chloride and gives the same identical product as the active and inactive amyl chlorides. The active chloride under these circumstances loses HCl and becomes amylene, which unites directly to produce tertiary isoamyltoluene. The inactive chloride not only loses HCl but undergoes a molecular rearrangement to yield this body. From the mode of its formation its constitution is easily deduced. It is dimethylethylmetacresylmethane.—*Bull. Soc. Ch.*, II, xlii, 213, Sept., 1884. G. F. B.

6. *On the Electro-magnetic Rotation of the plane of polarization of light.*—A. Kundt has examined this subject with reference to the magnetic metals in general and his conclusions are as follows:

(1) The greater part of isotropic solid bodies, fluids and gases which have been examined turn the plane of polarization in the positive sense.

(2) A strong concentrated solution of iron chloride turns it in the negative sense. The negative turning of other magnetic salts is apparent from the diminution of the positive turning of the medium of solution.

(3) Oxygen turns the plane in the positive direction.

(4) The plane of polarization of light which is passed through iron, cobalt and nickel is turned in the positive direction.

(5) Negative turning results from perpendicular reflection from an iron magnetic pole. This is true for cobalt and nickel.

(6) With transmission of the rays through iron, as also with reflection from iron, the rotation dispersion is anomalous; that is, the red rays are more strongly turned than the blue.

(7) The complicated phenomena that are seen when light is reflected at an angle from metallic pole pieces of magnets result from the light passing through a thin layer of the metal in which a negative turning takes place.—*Ann. der Physik und Chemie*, No. 10, 1884, pp. 228-252. J. T.

7. *A new form of Polariscope.*—At a meeting of the American Academy of Arts and Sciences, held in Boston, October 8, Professor Edward C. Pickering described a very sensitive polariscope which he has employed to show the varying polarization of the sky at sunset. A double image prism is so placed that the images of an aperture covered with a comparatively coarse grating (made by cutting lines in tin foil), will overlap. The eye-piece is a Nicol's prism which is mounted on a graduated circle. This eye-piece is turned until the images of the aperture disappear, or until the field is of a uniform tint. This instrument can also be used as a photometer. J. T.

8. *Conductivity of Tourmaline for Heat.* — Theoretical conclusions have led Professor S. P. Thompson and Professor O. J. Lodge to believe that there exists in tourmaline a unilateral conductivity for heat in the direction of the principal axis, and that the conductivity in the direction from the analogous pole to the

antilogous pole is different from the conductivity in the opposite direction. Franz Stenger has examined the subject, using an adaptation of Weber's thermo-electrical method, and concludes that the unilateral conductivity for heat in tourmaline is at most extremely small and probably does not exist.—*Phil. Mag.*, Nov., 1884, pp. 427–433. J. T.

9. *Helmholtz's dispersion theory.* — A. WÜLLNER shows from the observations of Langley that the equation between indices of refraction and wave-lengths given by Helmholtz, as the result of his dispersion theory, gives consistent results for the portion of the spectrum examined by Langley. The latter had shown that the equations of Briot, Cauchy and Redtenbacher do not give results consistent with actual measurement.—*Ann. der Physik und Chemie*, No. 10, 1884, pp. 306–312. J. T.

10. *The Infra-red Emission-spectra of Metallic Vapors;* by H. BECQUEREL.—Last year I submitted to the Académie des Sciences a short account of my first researches on the infra-red spectra emitted by metallic vapors, till then unknown.* Since that time I have investigated the subject still further by making use of a special spectroscope, which shall be described in a future paper; I will simply mention here, that the method consists in throwing the spectra, about to be examined, upon a suitable phosphorescent substance, which has been previously rendered luminous, and in observing the temporary excitation, which precedes extinction, under the influence of the infra-red rays. The lines and bands of the emission-spectra then appear brilliant, and can be examined with the microscope.

In experimenting on different phosphorescent substances, notably certain preparations of sulphide of calcium, I found some much more sensitive than others for infra-red rays. These substances have permitted me to determine directly the wave-lengths for the more brilliant lines of several incandescent metallic vapors (potassium, sodium, cadmium), by using the diffraction-spectra produced by a very beautiful metal grating of Mr. Rutherfurd's, which was kindly lent be by M. Mascart.

For other metals, the spectra were obtained by means of a bisulphide-of-carbon prism. The positions of the lines were referred to those of the potassium and sodium lines, and to the positions of the bands and characteristic lines in the infra-red region of the solar spectrum, as well as the absorption-bands of samarium; the wave-length for each line was then determined by interpolation with great accuracy.

The wave-lengths for the lines and principal bands in the infra-red of the solar spectrum have been again determined by means of the grating, which had been placed at my service; and the more sensitive substances in my possession have permitted me to extend these measurements much further than I was enabled to do in my previous researches.† I propose to return shortly to this work, which has led me to rectify several numbers relating to wave-lengths at the less-refrangible end of the spectrum; I will only give here the wave-lengths of the principal lines used for reference: the band indicated by A'' in my former memoir is made up of two bands, whose wave-lengths are from 0·00115 to 0·00119 millim., and from 0·001132 to 0·001142 millim.; the large band A''' extends from 0·001351 to about 0·001400 millim., and the extreme band A^{iv} from 0·001800 to about 0·001900 millim. The wave-lengths of the characteristic absorption-bands of samarium, directly determined, are: from 0·001079 to 0·001097 millim. for the first, and from 0·001239 to 0·001267 for the second.

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* Comptes Rendus, t. xcvii, p. 71.

† Annales de Chimie et de Physique, 5ᵉ série, t. xxx, p. 5.

The metals were volatilized in the voltaic arc. The intensity was such, that I could make use of a very narrow slit, and observe, on the phosphorescent substance, interesting details. In this case, it is necessary that the image of the line be brought to an exact focus on the phosphorescent screen; for, unless this be so, the results are not observable when the slit is narrow. I have not yet been able to invent a suitable arrangement for giving a complete and definite image of the whole of the infra-red spectrum; but, by repeated trials, it was possible to obtain sufficiently distinct images of the groups of lines which are to be examined. I am occupied, however, at the present moment with an improvement, which will admit of still greater delicacy.

Wave-lengths of the Principal Emission-rays of several Incandescent Metallic Vapors.

	Wave-length.	
POTASSIUM.	770 1098 1162 1233	Lines very brilliant.
SODIUM.	819	Visible to the naked eye. Capt. Abney has photographed this line and discovered that it is double.
	1142.	
STRONTIUM.	870 961 1003 1034 1098	Lines and bands feebler; approximate wave-lengths
CALCIUM.	858–876 883–888	Broad bands, probably groups of lines.
MAGNESIUM.	899	Very intense, perhaps compound.
	1047 (?)	Very feeble.
	1200 1212	Broad and perhaps double. This group resembles group *b*.
ALUMINIUM.	1128 1361·5	Broad and intense, perhaps compound.
ZINC.	1125 1306	
CADMIUM.	1850.	
LEAD.	1059·8 1087 1133	Very intense.
	1221 1229	Feebler group. Approximate wave-length.
THALLIUM.	1150.	Approximate wave-length.
BISMUTH.	837 973	Approximate wave-lengths.
SILVER.	771 825	Visible to the naked eye.
TIN	1083 1199	

The preceding table contains the wave-lengths for the most intense lines, bands or groups of lines which characterize the spectra of several metallic vapors. The numbers are expressed in millionths of a millimeter, and are generally exact to one or two millionths of a millimeter.

Nickel gave several rather feeble bands or groups of lines; while iron, in our experiments, gave no band sufficiently intense to examine.

The results, indicated above, show how rich the field of research is which the phenomena of phosphorescence open up in the invisible part of the infra-red of the spectrum, and which, alone, covers an interval of wave-lengths greater than the visible and ultra-violet parts together.

Besides the interest it may excite by proving the existence of these rays, of which the wave-lengths are considerable, in the spectra of metallic vapors, this research, more than any other, is of the kind which give most valuable information concerning the unknown laws that govern the vibratory motion of incandescent vapors.—*Comptes Rendus*, Aug. 25, 1884; *Phil. Mag.*, Oct. 1884.

11. *Determination of the Wave-lengths of the principal lines and bands in the Infra-red portion of the Solar Spectrum. Note* by M. HENRI BECQUEREL.—In a recent communication to the Académie des Sciences* on the lines in the infra-red part of the spectrum formed by incandescent metallic vapors, I had occasion to point out some corrections which I had been led to make in the numbers adopted in a previous research† for the wave-lengths of several lines and bands in the solar spectrum. I now give a *résumé* of my new determinations of the wave-lengths of the principal lines and bands in the infra-red portion of the solar spectrum.

The infra-red portion of the solar spectrum, from the group A to the extreme end of the visible part, shows, among other things, large absorption-bands. The two more-refrangible ones have already been split up into groups of bands and very fine lines; and it is probable that a more complete investigation would lead to a similar result for the two others. In my former researches I indicated these bands, starting from A, by the letters A′, A″, A‴ and A$^{\text{iv}}$.

The bands A′, A″, A‴ appear to have been observed by most physicists who have examined the infra-red region of the solar spectrum by thermoscopic methods, notably by J. Herschel, Fizeau and Foucault, Desains and Lamansky. The same bands were observed by my father in 1866 by applying methods relating to phosphorescence; but the values (varying considerably among themselves) which different physicists have obtained for the wave-lengths of these rays do not allow of the identification, with any certainty, of the results of their researches. In 1847

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* Comtes Rendus, August 25, 1884; Phil. Mag., October, p. 386.

† Annales de Chimie et de Physique, 5ᵉ série, t. xxx, p. 5.

Fizeau gave the number 0·001445 millim. for the wave-length of a band which appears to be the band A‴. On the other hand, my father obtained for this same band, by the phosphorographic method, numbers varying between 0·001400 and 0·001200 millim., and gave the number 0·001220 millim. for its most refrangible border. It was therefore necessary to determine these wave-lengths directly by using a grating.

In 1879 Capt. Abney prepared a very beautiful map of the infra-red portion of the normal spectrum; it was obtained by photography, and extended to about the wave-length 0·000980 millim. In my previous researches I was enabled, by the application of phosphorescence, to measure, in the diffraction-spectrum of a grating, to about 0·001000 millim.; but the feeble brilliancy of the spectra did not permit of my going further, and I adopted the number 0·001220 millim. for the most-refrangible border of the band A‴ which can be easily observed in the spectrum formed by a prism. The numbers above 0·001000 millim., published in the paper cited above, were obtained by means of an interpolation based upon this assumption.

In a memoir published in 1883 Mr. Langley deduces the wave-lengths of the bands A′, A″, A‴, A$^{\text{iv}}$ from their position in the spectrum formed by a prism by an ingenious method of graduation of his spectro-bolometer; and the numbers obtained by him, starting from 0·001000 millim., differed considerably from those given by our hypothetical interpolation. I then proposed to make these determinations again, by throwing the diffraction-spectra obtained by a grating on phosphorescent substances considerably more sensible for infra-red rays than those which were at my disposal during my former researches. These substances have allowed of my measuring, with a quite near approximation, the wave-lengths of the bands in question, as well as several of the finer lines; the numbers given by these experiments are near enough to those obtained by Mr. Langley with his bolometer, but the delicacy of the method of observation used by me is much greater.

The solar rays, concentrated upon a narrow slit, in the focus of a collimator were made to fall upon a beautiful grating, ruled on metal by Mr. Rutherfurd, which M. Mascart was kind enough to lend me. The rays, brought to convergence by a lens, then transversed a bisulphide-of-carbon prism, of which the edges were at right angles to those of the slit and the lines of the grating, and formed upon the phosphorescent substance a series of oblique spectra, in which the rays of the spectra of different orders were in juxtaposition and not superposed. The slit was sufficiently narrow to allow of distinctly seeing the principal lines of the luminous spectrum; and on comparing the position of the lines and bands in the infra-red part of the first spectrum with those of the known lines in the luminous part of the spectra of second and third order, their wave-length was obtained with an approximation which depended only on the accuracy of the scale-reading.

The following table contains the numbers obtained for the principal lines and bands. These numbers appear exact to within one or two millionths of a millimeter, and may be substituted for those which have been given in the publications of my previous researches.

Wave-lengths of the principal lines and bands in the infra-red part of the solar spectrum, expressed in millionths of a millimeter.

700·4.	A.
771.	
783.	
791 to 796.	
804.	
819.	(Sodium).
830.	
844.	
858 to 862	Corresponds to a calcium group.
876.	
898 to 900.	(Magnesium).
917 to 920.	Band or group of lines.
934 to 945.	A′. Group of lines and bands very near to one another.
950 to 965.	
968.	
992.	
1025.	
1069 to 1075.	
1115 to 1119.	A″. Group of two bands which appear to be those indicated by Capt. Abney as ϕ_1 and ϕ_2.
1132 to 1142.	
1142.	(Sodium).
1200.	(Magnesium).
1254.	
1354 to 1400.	A‴. Border distinct from 1351. Appears to be the band named ψ by Abney.
1440.	Feeble band.
1510 to 1560.	Group of bands.
1800 to 1880.	A^{iv}. Approximate numbers. This band has been called Ω by Mr. Langley.

The above results show that the phosphorographic method permits, when the phosphorescent substances are properly chosen, of the investigation of the infra-red part of the spectrum as far as thermoscopic and farther than chemical methods. This method has, further, an advantage that the others do not possess, namely, that of giving a complete image, at one time, of the part which is to be studied.—*Comptes Rendus*, Sept. 1, 1884; *Phil. Mag.*, Nov., 1884.

12. *On the Strain connected with crystallization and with the development of perlitic structure.*—Mr. FRANK RUTLEY has given (Quart. Journ. Geol. Soc., July, 1884) some interesting observations on the effect of incipient crystallization and the development of the perlitic structure in producing a state of strain in some vitreous rocks, as shown by the phenomena observed in polarized light. The observations were made upon a section of obsidian from Japan. This showed a considerable number of crystals under the microscope and about each of them the phenomena observed in plain polarized light indicated that a state of strain or tension existed in the glass. This strain may be produced by the formation of the crystals, the glass surrounding them showing double-refraction so caused; or in other cases it may be connected with the development of the perlitic structure, the same phenomena occurring within the perlitic area; or again there may be crystals surrounded by the strained glass and these areas bounded by perlitic fissures. The author concludes that perlitic structure

may be produced in three ways, in each case strain being the primary cause of it; they are: (1) Cooling along minute fissures; this seems to be the usual way where the perlitic structure pervades the whole rock, as in perlites. (2) Cooling around included fragments taken up in a lava flow; this seems to be merely a marginal structure connected with the fragments, and not affecting the rest of the rock. (3) By the tension in the surrounding mass when a crystal is formed; the formation of a crystal not necessarily involving perlitic fission.

The author gives an interesting instance of the development of structures in glass along fissures. He says: "Fifteen or twenty years ago a house was burnt down in the market-place at Dover; a small piece of plate-glass from one of the windows is seen, when closely examined, to be traversed by minute, irregular cracks like those in the artificially cracked, carmine-stained quartz of the French jewelers, known as rubace. When examined under the microscope, between crossed nicols, these cracked surfaces appear to be studded with great numbers of beautiful little spherules with a radiating crystalline structure, each traversed by the usual dark cross. That they follow the cracks is evident, because one has to focus down to them in tracing the crack from the upper surface of the glass downward. They are, however, really circular crystalline films like little flat wheels lying on the cracked surfaces of the glass. The phenomenon is superficial and seems only to follow the cracks. We may feel tolerably sure that the glass was not cracked in this manner before the house was burnt. The cracks are precisely such as would be produced in glass or rock crystal by heat and subsequent immersion in a cold solution; and these conditions would, in this case, be fulfilled by the fire and the play of water from the fire-engines. Whether those little circular crystalline aggregates represent crystallization set up actually *in* the glass, or result from the crystallization of some substance other than that of the glass, introduced in solution into the fissures, I am not prepared to say."

II. Geology and Mineralogy.

1. *The Copper-bearing Rocks of Lake Superior;* by R. D. Irving. 464 pp. 4to, with several colored maps and sections and wood-cuts. U. S. Geol. Survey, Clarence King, Director. Vol. v, of Monographs of the Geological Survey. Washington, 1883. —This Report contains the results of a careful survey of the so-called Keweenian series of rocks, which border the larger part of the western half of Lake Superior from Keweenaw Point to Duluth and from Duluth to Nipigon Bay. The rocks of the Animikie group, about Thunder Bay, are excluded, and referred to the Huronian age; and also the horizontal Lake Superior sandstones between Clinton Point and Duluth, which, with the similar sandstones of the southern half of Keweenaw Point and a coast region eastward, are made to be unconformable and

probably of the age of the Potsdam sandstone. The Report first gives a history of former geological investigations of the region and a full bibliography; and then treats of the distribution of the rocks, their kinds and stratigraphy, and all with great thoroughness. The petrographical part is specially interesting on account of the large amount of eruptive rocks in the Keweenian series, and also the unusual excellence of the colored microscopic illustrations. The basic eruptive rocks of the region are remarkable for their range of variation under what may be considered one type of rock. They are described under Rosenbusch's names—diabase, olivine-diabase, diabase-porphyrite (=porphyritic diabase), melaphyr, gabbro, and olivine-gabbro with anorthite rock. Professor Irving remarks that "all of the kinds, although distinct enough in the field are, lithologically considered, but phases of one kind of work," and all plagioclase-augite rocks, to which "the term 'basalt,' restricted by Rosenbusch to their younger equivalents, might be not improperly used." The diabase and melaphyr occur amygdaloidal, and figures on pages 311 and 326 represent the layers of successive outflows with the lower half solid and the upper vesicular. The gabbros are generally coarsely crystalline and sometimes contain orthoclase; the others are of all grades of texture. The anorthite rock is a coarsely crystalline, grayish-white rock occurring at points on the northwest shore of Lake Superior; it often consists wholly of anorthite, but sometimes has a little augite, and in one section a few grains of chrysolite were present. It occurs as masses cutting black gabbro and has included angular masses in the same rock. The acidic rocks are granite (one small locality); augite-syenyte and granulite or porphyritic granite; quartziferous porphyry, quartzless porphyry and felsyte—which terms mean: felsyte, both quartz-bearing and quartzless (the quartz usually in distinct crystals), and either porphyritic with feldspar crystals or not. The felsyte rocks are mostly of a pale or deep red, purplish red, or brownish red color; they occur at Mt. Houghton, on Keweenaw Point, in the Porcupine Mountains farther west, and on the northwest shore of the lake, and were a source of much material for conglomerates in the Keweenaw series.

The subject of the origin of the minerals in the amygdaloidal cavities and their successive formation, so well investigated by Pumpelly, was not particularly studied by Prof. Irving, and only a statement of Pumpelly's results is given.

The fragmental rocks of the series are made of granitic and felsitic material, and in part of material from the other igneous rocks, but are nowhere true quartzose sandstones; a fact indicating freedom from the long continued assorting action of waves and currents during the slow progress of accumulation such as makes beach and sand-flat deposits along ordinary coasts.

The question whether the Keweenian series is the equivalent of any part of the Cambrian group of Great Britain, or is older than its oldest beds, Prof. Irving leaves undecided, for the good reason that fossils, the only true criterion of geological age, are absent from the beds, and from all underlying beds; he says, accordingly, only this—older than the Potsdam sandstone and its equivalents. The Cambrian of Great Britain is of great thickness below the equivalents of the Potsdam sandstone; and the question has arisen among those who have considered the subject, whether the Keweenian beds are not the equivalents of the part of the Cambrian below the upper Lingula flags, that is, of the Lower Cambrian and Menevian groups of Great Britain, or of the Lower Cambrian alone. Should either prove to be a fact, the series is true Cambrian; and if the name Cambrian is to be used at all in American geology, this series may claim it better than any beds of later origin.

The colored maps of the Report are of the best style of the art, and the other illustrations are excellent.

2. *Note on the Paramorphic Origin of the Hornblende of the Crystalline Rocks of the Northwest;* by R. D. IRVING.—In my second paper on this subject in this Journal for February, 1884, in which I give an historical review of the matter, there is a quite important omission. In referring to the work of Streng on the Minnesota crystallines I failed to note that, besides the Duluth gabbro, Streng had described other rocks from Minnesota* in a number of which he found associations of augite and diallage with hornblende, of such a nature as to lead him to believe in the secondary origin of the latter. It is evident that Streng was by far the first to note this relation between hornblende and an augitic material in the rocks of the Northwest; not merely in greenstones but in granites and other quartz-bearing rocks. And not only this, for he describes *single* brown hornblende (with cores of diallage), which he evidently regards as altered from *single* diallages, though he speaks cautiously on the subject.† His words in conclusion are worth quoting:

"Das augitische Mineral ist überall als Diallag ausgebildet, dessen deutlichste Spaltfläche die stumpfe Säulenkante der es umhüllenden Hornblende gerade abstumpft. Die Verbindung beider Mineralien ist eine so unregelmässige, die Hornblende dringt in so schmalen Parthien in die Augitsubstanz ein, dass man sich des Gedankens nicht erwehren kann, hier sei die Hornblende aus dem Augit entstanden. Der Beweis für diese Ansicht wird aber erst erbracht sein, wenn es gelingt nachzuweisen, dass die äussere Umhüllung des ganzen Krystalls die Form des Augits an sich trägt. Würde dieser Beweis gelingen, dann würde man annehmen müssen, dass auch andere Hornblenden, welche keinen Augitkern mehr besitzen, aus Augit entstanden sein und dass bei ihnen die Umwandlung schon vollendet sei; d. h. dass die fraglichen Gesteine einstmals noch reicher an augitischem Minerale gewesen sein, als sie jetzt erscheinen." This was in 1876.

Madison, Wis., Oct. 7, 1884.

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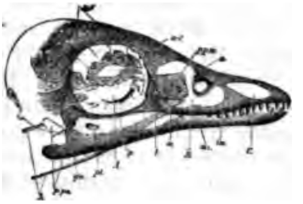
* Neues Jahrbuch für Mineralogie etc., 1877, pp. 31–56, 113–138, 225–242.

† Neues Jahrbuch, 1877, p. 240. See also for translation Eleventh Annual Report Geol. Survey Minn., p. 84.

3. *The Berlin Archæopteryx.* — The Geological Magazine for September last contains an abstract of a paper by W. Dames on the Archæopteryx discovered in 1877 in the lithographic stone at Blumenberg in Bavaria (the same rock that afforded the specimen described by Professor Owen), which is illustrated by a plate showing the head with the tooth-bearing jaws, from which the accompanying figure of the head is taken, reduced in size. The length of the head is about two inches. When examined by Carl Vogt and Professor Marsh only two of the teeth were visible. By the removal of the rock, 12 teeth in a row are now exposed from the extremity of the beak backward out of the original number 13. The edge of the jaw carrying the teeth is 16^{mm} long; and the teeth, which are very nearly alike in size and shape, measure 1^{mm} in length and 0·5 in width. On the lower jaw, portions of only three teeth are visible, but enough to make it almost certain that the teeth of the jaw corresponded with those in the upper. The length of the jaw is 35^{mm}. The evidence seems to prove that the teeth are implanted in distinct alveoli.



A, orbit; *B*, antorbital foramen; *C*, nasal opening; *pf*, parietal and frontal; *n*, nasal; *im*, intermaxillary; *l*, lachrymal; *m*, maxillary; *p*, palatine; *ppm*, palatine process of maxilla; *pt*, pterygoid; *qu*, quadrate bone; *scl*, sclerotic plates of eye; *mt*, lower jaw; *ppa*, post-articular process of mandible; *h*, hyoid bones.

The author states that the skeleton appears to be more closely connected with living birds than with the toothed birds of the Cretaceous period described by Marsh.

4. *The deposition of Ores;* by J. S. Newberry, (School of Mines Quarterly for May, 1884, New York).—Dr. Newberry's extensive knowledge of the ore deposits of western North America gives great weight to his conclusions as to their positions and origin. In this valuable paper he discusses the bearing of the facts he has observed on the theory which attributes the origin of the ores to the leaching of adjacent *igneous* rocks. He shows, by a mention of many examples, that different sets of fissure veins widely diverse in character cut the same country rock; that the same vein often traverses a series of distinct formations without any essential change; that many veins have no connection with any igneous rock; that the most extensive igneous ejections have no associated ore deposits; and favors the view of Richthofen that the filling of many of the veins was the result of "the leaching of deep-seated rocks, perhaps the same that enclose the vein above, by highly heated solutions, which deposited their load near the surface." The region, he observes, is conspicuous for the number of its hot springs, and it is evident that these are the last of the

series of thermal phenomena connected with the great volcanic upheavals and eruptions since the beginning of the Tertiary age." The heated moisture of the Comstock lode is heated by coming in contact with hot rocks at a lower level than the present workings, and the hot sources thus opened are doing to-day what they have been doing in the past, though less actively—bringing toward the surface the materials taken into solution in a more highly heated zone below. Hot, not cold, waters are doing and have done the chief part of the work in the formation of mineral veins.

5. *Some instances of Atmospheric action on Sandstone;* by M. E. WADSWORTH. (Proc. Boston Soc. Nat. Hist., vol. xxii, Feb. 7, 1883.—The object of this brief paper is simply to place on record some observations made a number of years ago, and to call the attention of others to the subject, in the desire that similar facts may be observed and more fully studied elsewhere.

That ordinary atmospheric agencies produce a greater effect upon rocks of a siliceous character than is generally believed, I have long deemed probable. This conclusion has been derived from field observations, especially upon sandstone and quartzites.

As examples of the power of the ordinary atmospheric agencies over rocks I would cite some cases observed by me in 1871, '72 and '73 near Mazomanie, Wisconsin, in the friable St. Peter's and Potsdam sandstone. The St. Peter's sandstone is composed almost wholly of a pure quartz sand, and in the outliers of it found on the hilltops south of the town, the parts covered by the soil were more or less friable and the grains distinct; while the exposed portions of the same blocks and slabs were greatly indurated, the grains almost obliterated, and the rock possessed the conchoidal fracture and other characteristics of a quartzite.

The Potsdam sandstone east of the town likewise possessed similar characteristics. In this, concretions of an indurated character were found forming on the surface, in size from three-fourths of an inch to an inch in diameter; while in the sandstone a few inches only, their rudiments could be observed in minute spherules, and a few inches farther in the sandstone was incoherent, easily crumbling under the touch and showing no trace of concretionary structure. At another locality the sandstone showed in cavities formed by weathering a distinct lining of quartz crystals, while a few inches beneath the surface the rock had the common friable character. The formation of these crystals, as well as the surrounding surface induration of the rock, is to be attributed to atmospheric agencies; as hot waters would have consolidated the sands beneath, and not as is seen extensively in that vicinity only the surface rock left by denudation. In the autumn of 1872 a block of clear white Potsdam sandstone was found on the side of a hill, the protected side of which was friable, while the other sides, especially the one most exposed to the prevailing storms, was nearly a quartzite. This block was only about two feet square, and as a test of the correctness of the above conclusion the indurated surface was broken off, and a comparatively friable surface exposed. This locality was visited the following spring when it was found that this fresh surface was much indurated and approached toward a quartzite.

This change had taken place in the few months that had elapsed since the fractured and friable surface had been exposed and there could be no doubt that the change was due to the action of the elements. Many observations were made regarding the induration of these sandstones, which are not here given, but all tended in the same direction—to show that atmospheric agencies exercised a strong indurating influence upon the surface and immediately underlying portions.

6. *On the Structure of English and American Carboniferous Coals;* by Edward Wethered, F.G.S., F.C.S. (Brit. Assoc., Montreal Meeting, 1884.)—With a view of testing the "Spore Theory" of the origin of coal, as propounded by Professor Huxley, the author had obtained a portion of the "better bed" seam intact for a thickness of ten inches from the top. He had examined this inch by inch, by preparing thirty-three microscopic sections. At the top was three and one-half inches of dull lustrous coal, termed "laminated coal." This the author found to be practically a mass of macrospores and microspores. Below this there was a change in the character of the seam. Spores became less numerous; in places they were scarce, the mass being made up of vegetable tissue and a substance to which the author gives the term "hydrocarbon." He could not, therefore, support Professor Huxley in saying that the "better-bed" coal was "simply the sporangia and spore cases of plants." The assertion would, however, apply to the first three and one-half inches of the seam. The "splint coal" from Whitehill Colliery was a better example of a spore coal than the "better-bed." The bottom stratum was four inches thick, and presented a dull luster with thin bright layers traversing at intervals. The dull portion was a mass of spores and spore cases, but these did not enter the bright layers. A vertical section cutting a bright layer, bounded on either side by dull lustrous coal, showed plenty of spores in the dull coal, but in the bright not one was detected. The second bed in this seam was one foot thick; it was of a brighter luster than the four inches below, but two layers could be distinctly made out, one more lustrous than the other. In the dullest of the two spores were found, which, however, were less numerous than in the bed below, and were, also, of a different variety. In the bright layers the spores were absent. The top bed of the seam was also one foot thick, and might be defined as a mass of spores, chiefly microspores, except in the bright layers. The American coals examined were collected by the author from the Warrior Coalfields of Alabama, and from near Pittsburg, Pennsylvania. The same structural affinities were noticed as in the English coals, and the author therefore came to the conclusion that the English and American Carboniferous coals had a common origin.

The spores in the coal from both countries were closely allied.

Some microspores from Alabama were identical with those which occur in the lower bed of the Welch "four feet" seam. A feature in spores obtained from all the coals was the triradiate markings which they exhibited. Whether this was to be regarded as superficial or not, it was very characteristic of them, and was, therefore, to be considered in attempting to ally them with modern vegetation.

7. *On the Geology of South Africa;* by T. RUPERT JONES, F.R.S., G.S., etc.—The contour of the south coast is parallel with the outcrop of the strata in the interior, from Oliphant's River (31° 40′ S. lat.) on the west coast, southward to the Cape, and then eastward to about 33° 30′ S. lat. Here the edges of the strata, formerly bending round to the north, have been swept away to a great extent; but their outcrop is again seen on the east coast at St. John's River (31° 40′ (S. lat.), where they strike northeastwardly through Natal, probably far up the country.

(1.) Gneissic rock and the *Namaqualand Schists* apparently underlie the others, coming out on the northwest, and exposing a narrow strip on the south coast. (2.) Mica schists and slates, interrupted by granites here and there, form a curved maritime band, from about 30 to 70 miles broad, and are known as the *Malmesbury Beds* (Dunn). These and the beds next in succession (the *Bokkeveld Beds*, 3) are overlain unconformably by the *Table-Mountain Sandstone* (4), 4,000 (?) feet thick, which forms patches and extensive ridges, and possibly dips over No. 3, to join No. 5, the *Witteberg Beds.* Nos. 3 and 5, together about 2,100 feet thick, lie parallel, and form a concentric inner band. The former contains *Devonian* fossils; the latter is probably of *Carboniferous* age (with *Lepidodendron*, etc.), and forms the Wittebergen and Zwartebergen in the Cape district, and the Zuurbergen in Eastern province.

The *Ecca Beds* (6) come next; Lower series, 800 feet; Conglomerate beds (*Dwyka*), 500 feet; Upper series, 2,700 feet; conformable with No. 5; in the south much folded, and in undulations throughout, until it passes under the next set of beds, No. 7, in some places 50 miles to the north. The Ecca beds have fossil wood and plant remains in abundance here and there, but these have not been clearly determined. This series has not been well defined until lately, and even now its limits are not fully determined. It includes the Karoo Desert, and therefore takes in the lowest members of Bain's great *Karoo formation*, Nos. 12 and 14 of his map (1856), or the 'Ecca,' 'Koonap,' and part of the 'Beaufort' beds of Jones (1867). The series No. 7, horizontal and unconformable on the Ecca beds at the Camdeboo and elsewhere, retains the name of *Karoo Sandstones;* and, after a width of about 40 miles, is conformably surmounted by a set of somewhat similar beds (8) in the Stormberg; and thus No. 7 should be regarded as the *Lower*, and No. 8 the *Upper Karoo sandstones.* The latter end off northward in the Draakensberg, Natal, Orange-Free-State, the Transvaal, and Zululand, with the still horizontal *Cave sandstone* and associated beds. The *lower Karoo sandstones* probably thin away northward beneath the others. Below the *Karoo sandstones*, and dying out southward near the Cambdeboo (Professor Green), are the Shales (7*), which constitute the country around Kimberley, described as the 'Olive shales' of the Karoo Formation,' by G. W. Stow. These die out northward against the old rocks of Griqualand-West and the Transvaal. They contain Glacial conglomerates in their lowest (earliest) beds, in Griqualand-West, just as the Ecca series has its great Glacial conglomerate (the *Dwyka Conglomerate* in No. 6) in its lowest portion. As the *Stormberg beds* (8) lie upon the *Olive* or *Kimberley shales* (7*) in the Orange-Free-State, the *Lower Karoo sandstones* (7) must die out northward. The *Kimberley shales* contain some reptilian bones and plant remains, and some coal on the Vaal; the *Karoo sandstones* are rich with Dicynodont and other reptilian bones, and have some fish remains; and their upper portion (*Stormberg*) contains Ferns and Cycadeous leaves, and some seams of coal. A fossil mammal also has been found in this series. Throughout its range the *Karoo Series* is traversed with igneous dykes.

Limestones and sandstones (9) with fossils of nearly pure Jurassic, but with some of Cretaceous type, occur unconformably in the Eastern province. Their fossil flora is like that of the *Stormberg Beds.* Cretaceous strata (10) are known on the Natal coast; and Tertiary and post-Tertiary deposits (11) from several patches on the east, south and west coasts.

8. *Miniature domes in Sand.*—Mr. T. Mellard Reade, in the Geological Magazine for January last, describes domes of sand 3 inches across and ½ an inch high, resting on blue clay, on a smooth sandy shore, which he attributes, with reason, to a lifting of the sands by air imprisoned between the clay and the moist surfaces of the sand; water, percolating, from the line of cliff 6 to 10 feet off, along the clay forcing the interstitial air upward into a flat bubble and raising the sand above. Mr. Reade states that on trial he found that a bottle holding 7 ounces of *perfectly dry* sand well shaken together would hold in its interstices 2 ounces of water, the ratio of sand to water in bulk being, therefore, about 7 to 5.

9. *A Treatise on Ore Deposits;* by J. ARTHUR PHILLIPS. 652 pp. 8vo, with numerous illustrations. London, 1884, (Macmillan & Co.)—The author of the well known Manual of Metallurgy, presents in this new work a general account of the various kinds, and modes of occurrence and associations, of ore deposits, a review of theories as to the formation of mineral veins, and special descriptions of the principal mining regions of the world. A comprehensive work of the kind has been greatly needed, there being none in the English language of more recent date than Professor Frederick Prime's translation of the volume by Von Cotta. The work fulfills well its purpose both as an elementary and descriptive treatise. The part on the mines of the United States and Mexico

is the least satisfactory. It covers but 60 pages, which is a small allowance considering the variety, extent and peculiar character of the ore-deposits. Mr. Phillips's visit to the country some years since has aided him in writing up the subject; but another visit, preparatory to the present treatise, would have secured for it greater thoroughness and precision, since the new developments during the past decade have been great.

10. *Lesquereux on the Coal Flora of Pennsylvania and the United States.*—The third and last part of the Coal Flora of the Pennsylvania and the United States, by Leo Lesquereux has been published, as volume III P, of the Reports of the Second Geological Survey of Pennsylvania. It is a fine volume of 280 pages with 24 8vo. plates, completing the work in 976 pages and 111 plates. The first two parts, published in 1880, have been widely distributed and are now well-known. This last one adds descriptions of a large number of very interesting new species, the most of them figured, some corrections and additions to a few of the species already published, a table of species referred to formations, an enumeration of all the species found at each locality mentioned, and a revised index for the three volumes of generic and specific names referring both to pages and to plates.

11. *Lithological Studies: a description and classification of the Rocks of the Cordilleras;* by M. E. WADSWORTH. 208 pp. with 33 pp. of analyses and 8 plates. 4to. Cambridge, 1884 (Memoirs of the Museum of Comparative Zoology at Harvard College, vol. xi, Pt. I).—This work as stated by Professor J. D. Whitney, in an introductory note, is a continuation of the publications of the Geological Survey of California begun in 1860. The part already published, however, is only in small part devoted to the description of Californian rocks, but is in fact principally a discussion of meteorites. It contains an extended discussion, in the successive sections of chapter I of the structure of the earth, the origin and alteration of rocks, and of their mineral constituents, the value of chemical analyses of rocks, the methods of classification based upon mineral composition, geological age, with the conclusions adopted by the author as to the true method of lithological classification. Chapter II takes up the siderolites and pallasites; chapter III the peridotites, and chapter IV the basalts. The "rocks" described under the above heads are mostly meteorites and the author has collated with much thoroughness the results of the investigations of others and has added to them observations of his own. In regard to the origin of meteorites, he regards "the sun, or some similar body, their most probable source." The tables in the close of the volume, covering pages 1 to 33, contain a long series of analyses of chromite and picotite, showing their close relation to each other, and also of meteorites and terrestrial rocks, mostly the former. The colored plates are well executed.

12. *Carboniferous Cockroaches and Myriapods.*—Professor S. H. Scudder has a paper in the Memoirs of the Boston Society of

Natural History, vol. iii, No. ix, (March, 1884), on new species of Cockroaches of the genus *Mylacris*, and on Myriapods of the genera *Trichiulus* and *Palæocampa*. The Myriapods are from Morris, Illinois, and the Cockroaches from Pittston and Cannelton, Pennsylvania and Morris, Illinois. In view of the characteristics of Palæocampa, it is remarked that, although so ancient and peculiar a type, the dermal appendages are of extraordinarily high organization, and further that the divergencies of structure among Carboniferous Myriapods was as great as among existing species. No trace of Myriapods has been found in this country below the Carboniferous; but they are known from the Old Red sandstone of Scotland.

13. *Macfarlane's Geological Railway Guide.*—JAMES MACFARLANE, Towanda, Pa., has commenced revising his American Geological Railway Guide for a second edition. He would be glad if persons who have used the book and made notes of corrections and additions, would send them to him; or if it will be a saving of labor, it will be a great favor to him if they will send him their copies of the book by mail, which he will return and refund all postage.

14. *On the Composition of Herderite.*—The doubt in regard to the true composition of herderite (pp. 318 and 401 of this volume) has at length been removed by Dr. Genth. The results of his analytical work, recently published, confirm those first given by Mackintosh and go to show that Winkler's are entirely untrustworthy. Four analyses were made by Dr. Genth upon quantities of the mineral, respectively, 1·033, 0·8608, 0·3303, 0·5860 grams, and the results are given below, together with the analyses by Mackintosh and Winkler.

	Stoneham.						Ehrenfriedersdorf.
	I	II	III	IV	Mackintosh.	Winkler.	Winkler.
P_2O_5 =	41·76	43·01	43·38	43·43	44·31	41·51	42·44
BeO =	14·60	15·01	15·17	15·04	15·76	14·84	8·61
Al_2O_3 =	0·17	0·22	0·09	0·20	....	2·26	6·58
Fe_2O_3 =	0·48	0·31	0·49	0·15	....	1·18	1·77
MnO =	0·09	0·08	0·12	0·11	....	....	....
CaO =	33·96	34·06	33·74	33·65	33·21	33·67	34·06
H_2O =	....	....	?0·61	?0·61	....	6·59	6·54
Fl =	....	?6·04	....	8·93	11·32	....	....
				102·12	104·06		
Less O =				3·76	4·76		
				98·36	99·84		

Dr. Genth gives in detail the method of analysis followed by him, and in conclusion says:

"The analysis made by Mr. Mackintosh and myself show that herderite is anhydrous beryllium-calcium phosphate and fluoride—with traces only of alumina and ferric oxide and perhaps water. The traces of alumina are owing to slight admixtures of traces of mica and albite.

"Somewhat doubtful is the exact quantity of fluorine which it contains. Mr. Mackintosh determined its quantity from the excess of lime which he found. A determination which I have made in the same manner gave me a far lower result, instead of 11·32, only 8·93 per cent. My direct fluorine determination is probably too low, owing to the incomplete decomposition of the mineral by fusion with silica and sodium carbonate and the difficulties in the separation of fluorine from such a solution. A doubt also exists as to the 0·61 per cent loss by fusion with plumbic oxide, whether it is water or lead fluoride. As all my material was used up I could not attempt any other determination for clearing up these doubtful points.

"It is to be regretted that the results of Dr. Winkler's two analyses are so very unsatisfactory, and that he has sacrificed the very precious Ehrenfriedersdorf herderite by employing incorrect methods for his analyses. By ignition he has volatilized the greater portion of the fluorine, then by evaporation with nitric acid the rest may have gone (although nitric acid is less liable to drive off hydrofluoric acid than hydrochloric acid would be); therefore, when he subsequently tested for fluorine, there was no more left than sufficient to give a *doubtful reaction.* * * *

"Dr. Winkler does not state that he has tested his so-called *alumina* for its purity, which is unfortunate, or he would have found that a slight trace of it might have been present, but that the precipitate was nearly pure glucina. There can be very little doubt that the Ehrensfriedersdorf and Stoneham mineral are identical in composition. There is also a larger percentage of ferric oxide in Dr. Winkler's analysis than found by me. Might this not have come from the molybdic acid which he used? The ammonium molybdate—prepared from Merk's molybdic acid—which I use contains in 100^{cc}, 0·002 grms. ferric oxide. As I used measured quantities a corresponding amount of ferric oxide was deducted."

III. BOTANY AND ZOOLOGY.

1. *Catalogue of the Flora of Minnesota;* by WARREN UPHAM. Part VI of *Report of Progress of the Geological and Natural History Survey of Minnesota*, N. H. Winchell, State Geologist. Minneapolis. 1884. pp. 193, 8vo.—"Minnesota lies in the middle of the North American Continent, almost midway between the Atlantic and Pacific oceans and between the Gulf of Mexico and the Arctic Ocean, being distant a thousand miles or more from each of these grand bodies of water. . . . It lies between 43° 30′ and 49° north latitude, and between 90° and 97° west longitude. Its area is 84,286 square miles." "A moderately undulating country" on the whole, with an average elevation of about 1,275 feet above the sea; its lowest land, on Lake Superior, 602 feet above the sea, its highest is the Mesabi Range in the northeast, not far from that lake, which exceeds 2000 feet, while Itasca Lake, the head of the Mississippi, is about 1500 feet above the

sea, and that river at the southeast corner of Minnesota, 620 feet. "The warmest days of summer have a temperature of about 90° Fahr., but such days are rare; and the greatest cold of winter is −30°, or sometimes −40°. The annual precipitation as rain and snow is from 25 to 30 inches. . . . The soil throughout the greater part of Minnesota consists of glacial drift. . . . Forest covers the northeastern two-thirds of the State, approximately, while about one-third, lying at the south and southwest, and reaching in the Red-river Valley to the international boundary, as also the part of the valley farther north to Lake Winnepeg, is prairie." The three pines of the State are the Jack Pine, *P. Banksiana*, in its most favorable growth attaining 40 to 60 feet in height, but seldom exceeding a foot in diameter, good for fuel and not bad for railway ties; Red Pine, *P. resinosa*, 50 to 75 feet high but seldom over a foot in diameter, yet "it is considerably sawn for lumber" and used for piles, etc.; White Pine, *P. Strobus*, "common through the north half of the State," excepting at the west, "the largest as well as most useful of our trees, growing from 80 to 125, rarely 150 feet in height, and from 3 to 6 feet in diameter." There is also Black Spruce, a very little White Spruce, a very few trees of Hemlock Spruce, some Balsam Fir, very little Red Cedar large enough to be forest trees, and a good abundance of Larch and Arbor Vitæ. The grass of the prairies consists mainly of *Andropogon furcatus*, *Chrysopogon nutans*, *Bouteloua racemosa*, and *Stipa spartea:* in wet ground *Spartina cynosuroides* and *Leersia oryzoides* make the principal hay. "About eight per cent of the plants growing without cultivation in the State are introduced species." All this, and much other information we find in the well-arranged preface; which, moreover, opens with a history of the various publications touching the Minnesota flora, from Hennepin and Carver down to date. There is a good map, illustrating the distribution of prairie and forest, and the principal components of the latter. The catalogue is excellently planned and executed, very well printed, full of good observations, and characters are given in foot-notes of all species and genera which are not described in Gray's Manual, so that these two together supply the student's needs. From the "Review" at the end of the volume, we gather that 1650 species of Phænogamous and Vascular Cryptogamous plants are enumerated, belonging to 557 genera, and to 118 orders. The six largest orders are *Compositæ*, *Cyperaceæ*, *Gramineæ*, *Leguminosæ*, *Rosaceæ*, *Ranunculaceæ.* Deducting the introduced plants, 138 in number, the indigenous staple consists of 1512 species, in 502 genera and 117 orders. It is reckoned that 290 of the indigenous species are also European. This catalogue "claims to be merely a report of progress in an unfinished work." It makes good its modest claim. A. G.

2. *Repertorium Annuum Literaturæ Botanicæ Periodicæ*, curavit G. C. W. BOHNENSIEG, Custos bibl. Soc. Teylerianæ, Harlem.—This elaborate and well-digested index and guide to botanical publications in periodicals is still kept up with spirit by

the Teylerian Society. We have now received the seventh volume, of 522 pages, 8vo, with full indexes of names of authors and of genera of plants treated; this for the year 1878. With it, the first part of the eighth volume, of 211 pages, for a portion of the bibliography of 1879. The arrangement is clear and the elaboration thorough. A. G.

3. *Drugs and Medicines of North America; a Quarterly, devoted to the Historical and Scientific Discussion of the Botany, Pharmacy, Chemistry and Therapeutics of the Medicinal Plants of North America, their Constituents, Products, and Sophistications.* J. U. Lloyd, Commercial History, Chemistry and Pharmacy, C. G. Lloyd, Botany and Botanical History. Cincinnati, J. U. and C. G. Lloyd, 1884.—The title page on the cover specifies the nature and scope of this work. The form is imperial 8vo. The three parts of the first volume, now before us, bear the dates respectively of April, July and October, reaching to 96 pages. The fullness of the work may be judged of when we state that these pages are devoted to one natural family, the *Ranunculaceæ*, and that by no means completed. *Clematis Virginiana* begins the first part, *Hydrastis Canadensis* fills the larger part of the third. There are good figures. The second figure of *Clematis crispa* ought to be good, for it is copied from the best original figure extant, and the same may be said of others. There are some elaborate magnified views of microscopical sections. We are struck with the wonderful fullness of the historical and bibliographical matters, also with the statistics or general statements of the enormous amount of some of the herbs and roots which have been collected and sold. For instance, in about the year 1880 a great demand for Hepatica sprung up, and during the year 1883, one State supplied more than 30,000 pounds of the dried leaves of this plant, and it is estimated that 450,000 pounds were gathered or imported for our home market; all this of a plant which is essentially inert. And the total yearly collection of the root of *Hydrastis* "will not vary much from 140,000 or 150,000 pounds." At this rate an interesting and peculiar genus would before long be extinct. A. G.

4. *Das Botanische Practicum;* by Professor Strasburger. pp. 664. Jena, 1884, 8vo.—Taken all in all, this is the most remarkable hand-book in practical vegetable histology ever published. From beginning to end the directions are explicit and ample, in respect both to the sources from which material can be procured, and the treatment to which it must be subjected in investigation. The range is very wide, embracing all types of plants, giving to each a due proportion of space. Therefore, if a student goes carefully and faithfully through the whole treatise, he will be placed in possession of the more important facts relative to the structure, development, and growth of all classes of plants. But it is not alone the extent of the scheme of study which attracts attention; the extreme care with which every difficulty in the path of the independent student is either smoothed down or removed, is a

distinguishing feature of the book. Lastly, it must be said that it is in no sense a compilation. From first to last, it is constructed from new and fresh material, and by a master, whose name is associated with the successful treatment of the most difficult problems in vegetable morphology and histology. His recent contributions to our knowledge of the division of the nucleus are here given as if in his own laboratory, and the details are as minute in every respect as the most exacting student could possibly demand. A single illustration must suffice. In speaking of the fertilization of gymnosperms, the material for study is fully described, so that any one can know just how and when to select it, and how to preserve it for examination. Then follow full directions as to proper methods of dissection. It is as if a painstaking teacher were at the side of a pupil, showing him step by step how to advance from the most elementary to the most difficult parts of his subject. Those who are familiar with Strasburger's classical works on the division of the cell and on the cell wall must have felt that there is a lack of method in presenting the wealth of material, and that the author is sometimes apt to conjoin accounts of methods and results without sufficient attention to the requirements of the style naturally looked for in a scientific treatise. But this habit of thought lends a great charm to these discursive and almost colloquial conferences with the pupils, whom he takes into his confidence in this admirable guide. It is to be hoped that the promised English translation will be as well done as are the translations of some other recent German botanical works. G. L. G.

5. *The Essentials of Botany;* by Professor C. E. BESSEY. pp. 292, 8vo.—This is an abridgment of a useful work by the same author, published in 1880, and already noticed in this Journal. In the abridgment, two changes have been made to adapt it to a younger class of pupils than those for whom the earlier volume was designed; first, by replacing many technical terms by simpler equivalents; second, by furnishing hints as to progressive laboratory practice. Both of these steps are in the right direction. The volume is clearly written, and is quite abreast the recent advances or changes, both in structural and systematic botany. A considerable amplification of the directions for practical exercises would doubtless increase the usefulness of the work, since such practical exercises, faithfully followed by teacher and pupil, form the best introduction to the study of any branch of natural history. G. L. G.

6. *Ornithorhynchus and Echidna.*—The announcement of the discovery of oviparous reproduction in the Monotremes by Mr. W. H. Caldwell, made before the British Association at its Montreal meeting, is published in the South Australian Register (of Adelaide) of September 5, as a telegram from London; and in the same paper occurs a notice of the meeting of the Royal Society of South Australia, on Tuesday, September 2, which notice contains the statement that "Dr. Haacke laid a number of specimens on

the table, including an egg found in the pouch of a female Echidna, in support of the theory that the Echidna, although a milk-giving animal, lays eggs which are hatched in the pouch." In the same paper, of the 6th, Dr. Haacke (director of the South Australian Museum), publishes a notice alluding to the telegram and his own coincident announcement, and adding that his discovery of the eggs was made on the 25th of August last, in the mammary pouch (not in the uterus) of a living *Echidna hystrix*, received about the third of the same month from Kangaroo Island through Mr. A. Molineux." Dr. Haacke also remarks that "the old naturalists thought that the animals referred to were oviparous, but their belief had now been universally given up."

The South Australian Register of the 7th, contains an additional note, received as a telegram from Professor Liversidge, dated Sydney, New South Wales, Sept. 7th. This telegram states that Mr. W. H. Caldwell came to Australia for the express purpose of settling a long disputed question whether the Platypus (Ornithorhynchus) and Porcupine (Echidna) were born alive or hatched from eggs, and on August 29th, he telegraphed Professor Liversidge that the *Monotremata* (to which class the animals referred to belong) *are oviparous*, adding the request that the information be sent to the British Association, then in session at Montreal. The telegram adds that Mr. Caldwell is now in Northern Queensland, pursuing his investigations, at a station named Dangangald, two days journey from Camboon. Mr. Caldwell is the first recipient of the Balfour travelling Fellowship (established in honor of the late Professor Balfour) tenable for three years, he being "one of the most distinguished students of Natural History Cambridge University has produced, and especially capable in embryology. His proficiency led the British Association to commission him to try to solve the mystery of the Monotremes, and also to make further discoveries with regard to the Ceratodus. Mr. Caldwell "is likely to remain in Australia two years longer."

Mr. Theodore Gill, in *Science* for November 14th, reviews the history of the idea that the Monotremes were oviparous. He mentions that Geoffroy Saint-Hilaire, in 1829, published a paper, illustrated by a figure of an egg of the natural size, in the 18th volume of the Annales des Sciences Naturelles. It was received by him from Professor Robert E. Grant of London, who drew one of a nest of four obtained by a Mr. Holmes. Still earlier, the Rev. Dr. Fleming, in his Philosophy of Zoölogy (ii, 215) published in 1822, remarks that "if these animals are oviparous (and we can scarcely entertain a doubt on the subject, *as the eggs have been transmitted to London*), it would be interesting to know the manner of incubation"; and his belief led him to separate, in his classification of Vertebrates, the Monotremes from the Mammals. Mr. Gill states other facts bearing on the subject in his note.

7. *Organisms in Ice.*—Professor LEIDY stated that there had been placed in his hands, for examination, a vial of water obtained

from melting ice which is used for cooling drinking-water. From time to time, among some sediment taken from a water-cooler, the gentleman had observed what he supposed to be living worms, which he suspected were introduced with the water into the cooler, and not with the ice. Upon melting some of the ice alone, the worms were still observed, and the water submitted for examination was some that was thus obtained. Professor Leidy was surprised to find a number of worms among some flocculent sediment, mainly consisting of vegetal hairs and other debris. Besides the worms there were also immature Anguillulas, and a number of *Rotifer vulgaris*, all living. It would appear that these animals had all been contained in the ice, and had been liberated on melting. It was an unexpected source of contamination of our drinking-water, that Professor Leidy had previously supposed to be very improbable. The little worms he was not familiar with. They belong to the family of Lumbricidæ, and may be an undescribed species of *Lumbriculus*. They are white, or colorless, from 4 to 6 millimeters long, by a third of a millimeter in thickness. The body is divided into thirty segments, bearing podal spines, which form four rows, with three in each fasciculus, and divergent. The spines are curved at the root, pointed at the free end, and measure 0·05 to 0·06 mm. long. The upper lip is blunt conical; the terminal segment truncate. There appears to be no distinct girdle, but the third, fourth and fifth segments contain capsuligenous glands and other organs pertaining to the sexual apparatus.

Several dead worms swarmed in the interior with large, ovate, beaked, ciliated infusorians measuring from 0·5 to 0·6 mm. long by 0·04 to 0·048 mm. broad.—*Proc. Acad. Nat. Sci. Philad.*, 1884, p. 260.

IV. ASTRONOMY AND GEODESY.

1. *Report of Observations made on the Expedition to Caroline Island to observe the Solar Eclipse of May* 6, 1883; by WINSLOW UPTON. Washington, 1884. (Reprinted from vol. ii, of the Memoirs of the National Academy of Sciences.)—This report contains a statement of the results of observations undertaken to determine the longitude of Caroline Island, and also of observations on the meteorology of the island, and in addition a series of observations by three different methods on the Solar radiation. In regard to the last point, the author remarks:

"The following summary gives the conclusions derived from an examination of the results:

(1) The method of the black and bright bulb thermometers freely exposed in the air gives only an approximate determination of the solar intensity. This was expected, and is due to the constantly varying conditions of exposure, caused by the effect of the winds on convection currents.

(2) Violle's bulbs are affected by convection, but the effect is shown less than in freely exposed thermometers, on account of

the position of the thermometers within. The observations on the afternoon of May 2, when the air was almost perfectly still, show higher intensities than the corresponding times on other days, but the observations are not sufficient to indicate how much the results are influenced by this cause.

(3) The intensities by the conjugate thermometers seem also to be affected by the varying influence of convection, but in this case (and in the preceding also) direct experiments would give more information as to this effect than examination of these observations.

(4) The intensities by Violle's bulbs (see the curves) are smaller in the morning and greater in the afternoon than those by the conjugate thermometers. There is a marked difference in the time of the maximum readings, the Violle bulbs reaching the maximum one hour later than the conjugate thermometers. This shows that the former are sluggish in their action, and at any given time show the intensity not for that time but for a time already past many minutes. The sluggishness of the Violle bulbs was also indicated by the long time which was required after the passage of a cloud before their return to a normal condition.

(5) The curve corresponding to the intensities given by the conjugate thermometers represents the relative solar intensities as accurately as the observations permit for the period April 28 to May 3. It is impossible to give any mathematical estimate of the uncertainty of the numerical values which would be obtained from this curve. It is probable that the values are liable to an uncertainty of several hundredths, but not as great as a tenth. They may be accepted as the final values of the relative solar intensity obtained at Caroline Island. Expressed in terms of the 12·00 value they are as follows:"

Relative solar intensity at Caroline Island, April 28, *to May* 3, 1883.

Time.	Intensity.	Time.	Intensity.	Time.	Intensity.
A. M.		A. M.		P. M.	
7.00	0·47	10.30	0·94	2.00	0·93
7.30	0·57	11.00	0·97	2.30	0·90
8.00	0·66	11.30	0·99	3.00	0·87
8.30	0·73	12.00	1·00	3.30	0·82
9.00	0·80	P. M.		4.00	0·76
9.30	0·87	12.30	1·00	4.30	0·66
10.00	0·91	1.00	0·78	5.00	0·46
		1.30	0·96		

From the observed solar intensities was calculated the value of the "solar constant" as defined by Professor William Ferrel in his investigation of the theory of the conjugate thermometers, namely, the amount of heat received on a square centimeter of surface at the upper limits of the atmosphere expressed in small calories. The value obtained, reduced to the sun's mean distance, was

$$A = 2{\cdot}360.$$

Radiation observations were taken during the eclipse to determine what proportion of heat received by the earth was cut off by the concealing of the sun and also the shape of the curve representing the varying solar intensity. In regard to this subject the author states: "An examination of the observations and the results of the computation leads to the following conclusions:

(1) The readings of all the instruments were essentially the same at the close of totality, and agreed with the observed air temperature. This indicates that during the total phase no heat was received by the earth from the atmosphere, as far as these instruments allowed its measurement. It need hardly be said that the radiation instruments are not intended to show the effect of the heat of the corona, and are not sensitive enough for such refined measurement. Their use is to measure the effect of heat which is received from the sun and by reflection from the atmosphere—the heat which is a factor in causing vegetable growth; they do not claim a position as delicate physical instruments. The observations show that during the eclipse the amount of heat gradually diminished until practically none was received, and the temperature of night was attained.

(2) The maximum point of the curve in the first partial phase is at about 10.08 A. M., or four minutes after the first contact. This four minutes covers whatever tardiness the instruments possess, as well as the natural increase of solar heat in the morning, until it was overbalanced by the direct cutting off of a portion of the sun's heat. The minimum point of the curve is at about 11.40 A. M., or three minutes after the observed time of third contact. This time is somewhat uncertain, as from the nature of the case this portion of the curve is drawn arbitrarily, the intensities having become indeterminate. The second maximum is at 1.15 P. M., four minutes after the last contact was noted. The afternoon observations do not indicate as great intensities as the morning, as is further indicated by the computed diathermancy constants given below. The sky was observed to be quite hazy as the day advanced."

2. *New Form of Primary Base Apparatus;* by T. W. WRIGHT.—In Wright's *Treatise on the Adjustment of Observations* (Van Nostrand, New York), there is a description of a new form of primary base apparatus. The measuring bar is of metal packed in melting ice. The length of the bar will remain unchanged throughout the measurement as its temperature is constant, being that of melting ice. The same temperature can at any time be had at which to find the length of the bar in terms of the official standard of length. The apparatus might be constructed as follows: The measuring bar, a bar of steel 25^{mm} in diameter and 6^{m} in length, placed in a circular cast-steel tube $\frac{1}{8}^{m}$ in diameter, made stiff by bracing, but as light as possible. Along the top of this tube slots of about 75^{mm} in width would be cut to allow the introduction of ice around the bar. The hole for drainage would be at the center of the tube on the under side. For supports during the measurement two

trestles placed $1\frac{1}{4}^m$ from the ends would be best. Effects of flexure would be got rid of by having the graduation marks showing the length of the bar placed on the neutral axis of the bar. The reading microscopes, alignment apparatus, sector and level for determining the inclination of the bar during measurement, such as those made by Repsold for the U. S. Engineers. The mode of measurement the same as with the Repsold apparatus. The amount of computation necessary to reduce the measurements made in this way would be small in comparison with that required with the forms of apparatus at present in use. The scheme is entirely practicable in the United States, at least where ice is to be had everywhere at all seasons.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Extracts of a letter to J. D. Dana, from* Dr. B. A. GOULD, Director of the Observatory of the Argentine Republic, dated Cordoba, Oct. 4, 1884.—After fourteen years of an expatriation which I did not at the beginning intend should cover more than three, I see the end of the vast and expanded undertaking within reach. Its object has already been essentially attained, so that it would now appear that the end of the current year will see me either on my homeward way or very near to the commencement of the journey. Indeed I am cherishing the hope of personally welcoming the spring flowers of New England. . . . By this present time of writing, or very soon at any rate, you will receive four quarto-volumes of star-positions; and within about a month I hope to start a meteorological volume on its way. A huge mass of similar material will be left for the occupation of my successors in the two institutions. The manuscript of seven astronomical quartos I hope to leave ready for the press; and to bring with me for publication in the Northern hemisphere the General Catalogue of Southern Stars, which will complete the astronomical work. . . . .

2. *Sir William Thomson's Lectures on Molecular Dynamics.* —It is announced that a verbatim report of the eighteen lectures delivered by Sir William Thomson at the Johns Hopkins University, Baltimore, in October, 1884, is to be published from stenographic notes taken by Mr. A. S. Hathaway, and reproduced by the Papyrograph Plate Process. A bibliography of the subjects considered will also be given with the lectures. In all there will be about 350 pages, quarto. A few copies are offered for sale at $5.00 net. The edition is strictly limited to 300 copies, and orders therefore should be sent at once to the publication agency of the Johns Hopkins University, Baltimore, Md., U. S. A. Copies may also be procured from Messrs. Mayer & Müller, Französische Strasse 38, Berlin, W.; A. Hermann, 8 Rue de la Sorbonne, Paris; Trübner & Co., 57 Ludgate Hill, London.

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